Printed on Thin Paper for Foreign Circulation.

The Engineer.

Established 1856.

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 28, ESSEX ST., STRAND, LONDON, W.C. 2.

VOL. CLIII.—No. 3984] LONDON: FRIDAY EVENING, MAY 20, 1932 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES.

UNIVERSITY OF DURHAM.

Armstrong College, Newcastle-upon-Tyne.

LECTURER IN MECHANICAL ENGINEERING.

The Council of Armstrong College invite APPLICATIONS for a LECTURESHIP in MECHANICAL ENGINEERING in Grade C (£300-£25-£400). Duties to commence on 1st October, 1932. Ten copies of applications, and of not more than three testimonials, should be lodged not later than 28th May, 1932, with the undersigned, from whom further particulars may be obtained.

W. S. ANGUS,
Registrar,
8514 Armstrong College.

Northampton Polytechnic Institute,
ST. JOHN-STREET, LONDON, E.C. 1.

APPLICATIONS are INVITED for the POST of LECTURER in MECHANICAL and AERONAUTICAL ENGINEERING.

Candidates should be of good academic standing, and should have had suitable industrial experience. Qualifications in Aeronautical Engineering are essential.

Salary in accordance with the Burnham Scale for Graduate Teachers in Technical Institutions in London, less 10 per cent.

Conditions of appointment will be sent on request. Applications should be received by 31st May.

S. C. LAWS, M.A., M.Sc.,
8518 Principal.

In the High Court of Justice.—Chancery Division. Mr. Justice Luxmoore.

In the Matter of the Patents and Designs Acts, 1907 to 1928, and in the Matter of the Letters Patent granted to FREDERIK KAREL THEODOOR VAN ITERSON, of Heerlen, in the Province of Limburg, The Netherlands, Engineer, and GERARD KUYPERS, late of No. 1, Sleepervaest, Rotterdam, The Netherlands, but now of No. 5, Vaickenierstraat, Amsterdam C, temporary at Arundel Hotel, 8, Arundel-street, Strand, London, Engineer, and bearing the date 16th August, 1916, and numbered 108,863.

Notice is Hereby Given that it is the intention of the above-named GERARD KUYPERS to ask leave to present, and to PRESENT a PETITION to the High Court of Justice, praying that the TERM of the above-mentioned LETTERS PATENT may be EXTENDED. And NOTICE is FURTHER GIVEN that on the 15th DAY of JUNE, 1932, at 10.30 in the FORENOON, or so soon thereafter as he may be heard, the said Gerard Kuypers intends to apply to the Court for a day to be fixed, before which the petition shall not be in the paper for hearing. Notices of objection should please be lodged at the first opportunity, e.g., before the 25th day of May, 1932, and must be lodged before the 15th June, 1932, at the Chambers of Mr. Justice Luxmoore, Room 173. Documents requiring service upon the said Gerard Kuypers, pursuant to the Rules of the Supreme Court, Order 65A, Rule 3, may be served at Arundel Hotel, 8, Arundel-street, Strand, London, W.C. 2.—Dated this 10th day of May, 1932.

GERARD KUYPERS.
(14022) 125 8532

London County Council.

TENDERS are INVITED for the INSTALLATION of STEAM PLANT, STEAM, CONDENSE, BOILER FEED and WATER MAINS, &c., and MISCELLANEOUS WORK at Lambeth Hospital, Brook-street, S.E. 11.

Specification, form of Tender, &c., may be obtained on and after Friday, 20th May, 1932, on application to the Chief Engineer, The Old County Hall, Spring-gardens, S.W.1, upon payment of £1 by crossed cheque or order payable to the London County Council. (NOTE.—CASH WILL NOT BE ACCEPTED.) This amount will be returnable only if a bona fide Tender has been sent in and not subsequently withdrawn. Full particulars of the work may be obtained on personal application and the contract documents may be inspected before payment of the fee.

Remittances by post should be addressed to the Chief Engineer, The Old County Hall, Spring-gardens, S.W.1. Personal inquiries at Room 2, No. 3, Warwick House-street, Cockspur-street, S.W.1.

The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the Instructions for Tender and form of contract and in "The London County Council Gazette."

No Tender received by the CLERK of the COUNCIL at The County Hall, Westminster Bridge, S.E.1, after 4 p.m. on Monday, 6th June, 1932, will be considered.

The Council does not bind itself to accept the lowest or any Tender. 8529

Metropolitan Borough of Woolwich.

APPOINTMENT OF TWO ENGINEERS FOR PUBLIC BATHS.

The Council of the above Borough invite APPLICATIONS for APPOINTMENT of TWO ENGINEERS for the Public Baths (one at Woolwich and one at Plumstead) at a commencing wage of £4 10s. each per week, to act under the direction of the Baths Superintendent.

Applicants must be between 30 and 40 years of age and be fully qualified engineers, with experience of steam boilers, fittings, turning and general repair work.

Applications, in candidates' own handwriting, stating age, qualifications and experience, and accompanied by copies of not more than two recent testimonials, to be sent addressed to me at the Town Hall not later than Twelve Noon on Friday, 27th May, 1932, in envelope marked "Appointment of Baths Engineers."

Canvassing members of the Council, either directly or indirectly, will be a disqualification.

By Order,
ARTHUR B. BRYCESON,
Town Clerk.

Town Hall, Woolwich, S.E. 18,
12th May, 1932. 8531

Assistant Civil Engineer.

SERVICES of a TEMPORARY ASSISTANT CIVIL ENGINEER REQUIRED for River Wall Construction Work in Burma.

Candidates should be Chartered Civil Engineers of about 30 years of age, with suitable experience and sound practical knowledge of River Surveying as applicable to Construction of River Walls and Embankments.

Salary Rs. 750 per mensem with free quarters (Rupee equals about 1s. 6d.), the appointment being for about 2 years.

Selected candidate will be required to undergo a strict medical examination.

Applications, with copies of testimonials, to be submitted to Box Z.W. 651, c/o Deacon's Advertising Agency, 5, St. Mary Axe, E.C. 3. 8543

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.
ARRANGED FOR CARD INDEXING.

Worm Gear Contacts. (P. 546)
(S. MIALL.) THE ENGINEER, 20 - 5 - 32.

Transient Voltage Stresses in Power Transformers—No. IV. (P. 551)
(K. K. PALUEFF.) THE ENGINEER, 20 - 5 - 32.

Prettyboy Dam. (P. 553)
THE ENGINEER, 20 - 5 - 32.

Iron and Steel Institute—No. II. (P. 549)
THE ENGINEER, 20 - 5 - 32.

World Steel Trade. (P. 565)
(E. T. GOOD.) THE ENGINEER, 20 - 5 - 32.

Outdoor Sub-station Lattice Steel Structures—No. I. (P. 556)
(A. M. SPRUCE.) THE ENGINEER, 20 - 5 - 32.

Richard Trevithick. (P. 559)
(H. W. DICKINSON.) THE ENGINEER, 20 - 5 - 32.

Small Power Transformers. (P. 566)
THE ENGINEER, 20 - 5 - 32.

Cylinder Liner Wear. (P. 563)
(J. HOPE HARRISON.) THE ENGINEER, 20 - 5 - 32.

INDEX TO ADVERTISEMENTS, PAGE 75.

PUBLIC NOTICES.

The Civil Engineers Appointments Board, 8, Princes-street, Westminster, S.W.1, acting under annual licence from the London County Council, invites INQUIRIES from EMPLOYERS SEEKING the SERVICES of PROFESSIONAL ENGINEERS, either as Assistants or in more responsible positions.

All those whose names are accepted for entry in the Board's Register for employment possess qualifications which have been attested by means of scientific examinations, practical training, and experience. P2182

SITUATIONS OPEN.

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN THIS CLASSIFICATION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge and co-operation is asked for.

WANTED for Large Engineering Firm, a Fully qualified MAN, to Take Charge of Machine Painting. One accustomed to Machine Tools preferred. State salary required and references.—Address, P2423, The Engineer Office. P2423 A

COMMERCIAL MANAGER for Modern Gear Works; qualified engineer, under 35 years of age, energetic, experienced in Salesmanship, good organiser.—Write with full particulars, Box 992, c/o Barker and Howard, Sugar Loaf-court, E.C. 3. P2422 A

ENGINEER-MANAGER WANTED in Large Public Works to Control Fitters, Boilermakers, Blacksmiths, and Buildings Construction and Upkeep Department. Must have had similar position covering all these branches. No others need apply. State age and experience.—Address, 8530, The Engineer Office. 8530 A

TECHNICAL SALESMAN.—ADVERTISERS WISH to SECURE the SERVICES of a thoroughly trained TECHNICAL SALESMAN, to organise and direct a staff dealing with central heating problems in London and district. Age 35/45. First-class technical qualifications and experience essential. Tact, energy, and organising ability will ensure excellent prospects.—Write first to Box 2/A, with full details of education, professional training, and experience, GEO. KELLY and CO., 14, Victoria-street, S.W.1. P2428 A

SITUATIONS OPEN (continued)

DRAUGHTSMAN WANTED, with Crane Experience.—Apply, giving full particulars of experience, wages, and when free, to CHIEF DRAUGHTSMAN, John M. Henderson and Co., Ltd., King's Works, Aberdeen. 8544 A

SITUATIONS WANTED.

A HIGHLY QUALIFIED ENGINEER, with both civil and mechanical experience of waterworks, sewage disposal, irrigation, drainage, water power, and harbour works, with knowledge of conditions in India, Africa, and on the Continent, DESIRES an APPOINTMENT, preferably with London headquarters, where his proved initiative and long experience can be fully utilised. Highest credentials given.
Address, P2426, The Engineer Office. P2426 B

AN Experienced Combustion and Mechanical DRAUGHTSMAN, age 27, good technical and works training, 9 years D.O., mechanical stokers, Bailey walls, pulverised fuel, steel work.—Address, P2418, The Engineer Office. P2418 B

ENGINEER (35), A.R.S.M., B.Sc. (Lon.), M. Sc. (M.I.T., Boston), SEEKS PROGRESSIVE POSITION or consider PARTNERSHIP. Extensive experience, home and abroad, mining, chemical, and general works engineering, lay-out and operation stone crushing, screening, tarmacadam plants, steam generation, electrical plant, &c.—Address, P2431, The Engineer Office. P2431 B

ENGINEER (27), B.Sc., 5 Years' Experience, India, Ceylon, structural design and construction, general engineering, tea engineering and mills management, SEEKS suitable POST, home or abroad. Any job with prospects of advancement.—Address, P2421, The Engineer Office. P2421 B

EXCHANGE and Tariff Situation Enables MANAGING DIRECTOR of Company, formerly European distributors for large American electrical manufacturers, also representing leading manufacturers of specialities for refrigeration, oil burner and allied industries, to consider APPOINTMENT with British firm.—Address, P2422, The Engineer Office. P2422 B

ENGINEER, A.M.I. Mech. E., Shortly Disengaged after service in East, marine, D.O., cons. exper., int. comb., elec., steam, French, Arabic, SEEKS RESPONS. POST, home or abroad, with cons. engrs. or firm. Testimonials.—Address, P2424, The Engineer Office. P2424 B

SITUATIONS WANTED (continued)

ENGINEER, German, Diplom-Ingenieur (31), Speaks English, good knowledge of French, experienced in industries of many kinds, inspected material in Europe, formerly assistant of Technical College, Berlin, energetic, excellent references, ACCEPTS SECRETARY, REPRESENTATIVE'S POSITION, Europe or America.
Address, P2419, The Engineer Office. P2419 B

ENGINEER (25) SEEKS POST as DRAUGHTSMAN for light intricate mechanisms or maintenance of industrial plant; good college training, National Certificate and Diploma, thorough works and D.O. experience.—Address, P2425, The Engineer Office. P2425 B

EXECUTIVE ENGINEER, 18 Years' Experience on large South American mines; expert maintenance and operation at lowest costs.—Address, P2393, The Engineer Office. P2393 B

AGENCIES.

ADVERTISER DESIRES to GET in TOUCH with AGENTS or REPRESENTATIVES doing business with Architects, Consulting Engineers, big Industrial Concerns, &c., in London and Home Counties; only very brief particulars required in first instance.—Address, P2420, The Engineer Office. P2420 D

A VERY Old-established and Up-to-date FIRM of first-class standing, having offices in all industrial areas in the British Isles, is PREPARED to ACT as SELLING ORGANISATION for Makers of Saleable Products of any description. Able to carry stocks in London, Wales, Yorkshire and Northern Ireland. Correspondence invited, which will be treated confidentially.—Address, 8536, The Engineer Office. 8536 D

BRISTOL ENGINEER, Operating in South-West England, with considerable commercial and technical experience, DESIRES CHANGE from his existing Agency Principals for Electrical Machinery, Switchgear and Hydraulic Equipment. Advertiser has good records and strong business connections.—British makers of repute may obtain further particulars from Messrs. OSBORNE, WARD, VASSALL, ABBOT and CO., Solicitors, 41, Broad-street, Bristol. 8525 D

IMPROVE YOUR EXPORT BUSINESS. ADVERTISERS REQUIRE AGENCIES of Manufacturers of Steel Material or other bulk lines. Sound connection extending over many years with London exporters.
A good opportunity for works not represented or those contemplating making new arrangements.
Replies will be treated in strict confidence.
Address, P2430, The Engineer Office. P2430 D

MANUFACTURERS. — ADVERTISER, London Office, REQUIRES REPRESENTATION Cut, Rolled Screws, Precision Turnings, Parts; or Allied Trade. Fourteen Years Representing Swiss House. Good Connection.—Address, P2433, The Engineer Office. P2433 D

SOUTH AFRICA.

OLD-ESTABLISHED FIRM of ENGINEERS, with head office in Johannesburg and branches throughout the Union and Northern and Southern Rhodesia, at present representing several large British Electrical and Mechanical Manufacturers having augmented their engineering staff, are DESIROUS of EXTENDING their ACTIVITIES and would like to hear from firms interested in the development of business in these territories. Only first-class products considered.
Reply to "H.," S.L.S.S., Ltd., 6, Victoria-street, S.W.1. 8466 D

PATENTS

KINGS PATENT AGENCY, Ltd. (B. T. KING, Regd. Patent Agent, G.B., U.S., and Can.), "Advice Handbook" and consultations on Patents and Trade Marks FREE.—146A, Queen Victoria-street, London, E.C. 4. 45 years' ref. 'Phone: Central 0682. 6755 E

THE PROPRIETORS of BRITISH PATENTS No. 203,472, relating to a "Machine for Gauging and Sorting Bearing Rollers and other Articles," and No. 307,273, relating to "Apparatus for Feeding Rolls and the like to Gauging and other Machines," DESIRE to ENTER into ARRANGEMENTS by way of LICENSE or otherwise for the purpose of EXPLOITING the inventions and ensuring their full and practical development in this country.
All communications should be addressed to H. N. and W. S. SKERRETT, 24, Temple-row Birmingham. 8527 E

THE PROPRIETOR of BRITISH PATENT No. 264,721 is PREPARED to SELL the PATENT or to LICENCE British Manufacturers to work thereunder. It relates to apparatus for discharging boats.—Address: BOULT, WADE and TENNANT, 112, Hatton-garden, London, E.C. 1. 8538 E

THE PROPRIETORS of BRITISH PATENTS Nos. 196,195 and 208,086 are PREPARED to SELL the PATENTS or to LICENSE British Manufacturers to WORK thereunder. They relate to improvements in making bead cables for pneumatic tyres.—Address, BOULT, WADE and TENNANT, 112, Hatton-garden, London, E.C. 1. 8546 E

THE PROPRIETOR of BRITISH PATENT No. 267,342, dated April 16, 1926, relating to "A Counterbalance for Use on a Crank Shaft," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—Inquiries to B. SINGER, Steger Building, Chicago, Illinois. 8542 E

AUCTIONS, Page 76
MISCELLANEOUS, Page 2.
PARTNERSHIPS, Page 2.
EDUCATIONAL, Page 2.
WORK WANTED, Page 76
FOR HIRE, Page 76.
BUSINESSES and PREMISES (For Sale, etc.), Page 76.
FOR SALE, Pages 2, 4 and 76.

For Advertisement Rates see First Column Overleaf.

The Engineer

Annual Subscription Rates

(including postal charges).

Le prix de l'abonnement est accepté en livres sterling, ou dans la monnaie du pays d'origine au cours du change au moment de la commande.

Die Bezugsgebühren sind zahlbar in Pfundsterling oder in der Landeswährung des Bestellers, umgerechnet zum Kurse des Tages an dem die Bezahlung erfolgt.

Serán aceptados los abonos en moneda esterlina o su equivalente calculado en la moneda del páis de origen al cambio efectivo a la fecha de ponérse el pedido.

BRITISH ISLES ..	£3	5	0	
CANADA	£3	3	0	Thick Paper Ed.
	£2	18	6	Thin Paper Ed.
ABROAD	£3	7	6	Thick Paper Ed.
(except Canada)	£3	3	0	Thin Paper Ed.

AFRICA	Central News Agency. All Branches CAPE TOWN: Wm. Dawson and Sons, Ltd., 29–31, Long-street (Box 489) JOHANNESBURG: C. Juta and Co.
RGENTINE ..	BUENOS AIRES: Mitchell's Book Store, 576, Cangallo
AUSTRALIA ..	Gordon and Gotch (Australasia), Ltd. All Branches MELBOURNE: Robertson and Mullens, Elizabeth-street
BELGIUM ..	BRUXELLES: E. Graddon, 78, Rue du Marché-aux-Herbes BRUXELLES: W. H. Smith and Son, 78–80, Rue du Marché-aux-Herbes
CANADA	American News Company, Ltd. All Branches MONTREAL: Gordon and Gotch, Ltd., 334, Notre Dame-street, W. TORONTO: Wm. Dawson Subscription Service, Ltd., 70, King-street East TORONTO: Gordon and Gotch, Ltd., 81, Queen-street West
CEYLON	COLOMBO: Wijayartna and Co.
CHINA	HONG KONG: Kelly and Walsh, Ltd. SHANGHAI: Kelly and Walsh, Ltd.
DENMARK ..	Teknisk Presse Bureau, Ourøgade 34, Copenhagen.
EGYPT	CAIRO: Express Book and Stationery Store, 9, Chareh Maghrabi
FINLAND ..	HELSINGFORS: Akademiska Bokhandeln, Alexandersgatan, 7
FRANCE	PARIS: Boyveau and Chevillet, Rue de la Banque, 22 PARIS: Librarie Berger-Leverault, 229, bld. St. Germain PARIS: Brentano's, 37, Av. de l'Opera PARIS: Dunod, 92, Rue Bonaparte PARIS: W. H. Smith and Son, 248, Rue de Rivoli
GERMANY ..	BERLIN-LICHTERFELDE-WEST: H. Hermanns, Dahlemer Strasse, 64 A LEIPZIG: K. W. Hiersemann, Konigstrasse 29
HOLLAND ..	ROTTERDAM: Hector's Boekhandel, Noordblaak 59 ROTTERDAM: Techn. Boekhandel, "Plan C," Gelderschestraat 4
INDIA	BOMBAY: Thacker and Co., Ltd. CALCUTTA: Thacker, Spink and Co.
ITALY	MILAN: Ulrico Hoepli ROME: Maglioni and Strini, 307, Corso ROME: Fratelli Treves, Corso Umberto 1, 174 ROME: Fratelli Bocca TURIN: Rosenberg and Sellier, v. Maria Vittoria 18, and their Branches at Naples and Rome
JAPAN	Maruzen Co. All Branches
JAMAICA	KINGSTON: Educational Supply Co.
NEW ZEALAND	AUCKLAND: Whitcombe and Tombs, Ltd. Gordon & Gotch, Ltd. All Branches NAPIER: J. Wilson Craig and Co.
RUSSIA	LENINGRAD: Mezhdunarodnaya Kniga, Prospect Volodarsky, 53A MOSCOW: "Litisdat," Kousnetsky Most, 515
STRAITS SETTLEMENTS	SINGAPORE: Kelly and Walsh, Ltd.
SWEDEN	STOCKHOLM: A/B Wennergrens Journal-expedition, Stockholm 1 STOCKHOLM: A/B C. E. Fritzes Kungl., Hofbokhandel, Fredsgatan, 2
SWITZERLAND	BERNE: Joh. William De Groot Laupenstr., 5 ZURICH: Ross. Leibowicz, 4, Ankerstr.
UNITED STATES OF AMERICA	International News Co., 131, Varick-street, New York, N.Y., and all Branches

Entered as second-class matter at the Post Office, New York, N.Y., December 12th, 1896, under the Act of March 3rd, 1879 (Section 397, P.L. & R.)

*** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d. each, 5s. 3d. post free.*

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER in each calendar month.

ADVERTISEMENTS.

The charge for Classified Advertisements is 1/- per line up to one inch—minimum charge 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Thursday afternoon (the day before publication).

Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published annually in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

Postal Address, 28, Essex-street, Strand, London, W.C. 2. Teleg. Address, "Engineer Newspaper, Estrand, London." Tel., Central 6565 (8 Lines).

HERBERT

BUY OUT OF INCOME.

WHEN considering the purchase of machine tools and equipment, NEW OR SECOND-HAND, ask for particulars of our deferred payment scheme. We can refer to a number of SATISFIED CLIENTS AND REPEAT ORDERS.

ALFRED HERBERT LTD.
COVENTRY.

Single Nozzle Model VN Drayton STEAM DE-SUPERHEATER

1213

The Drayton Model VN De-superheater is available as a standard unit for small capacities. These units are small and compact and require very little space for fitting.

The Model VN De-superheater ensures an ample supply of dry saturated steam at a moment's notice. Whether the demand is for a full supply as in the case of breakdown of main turbines or for a small bleed to make up a slight shortage of process steam, the Model VN will instantaneously adjust itself to meet requirements.

When required for constant service it is equally satisfactory. The patent adjustable nozzle gives perfect atomisation at all loads from full to zero. The simplicity of the component parts and strong construction of the spray nozzle and regulator reduces the necessity for maintenance attention to a minimum.

(List 174/38 sent on request.)

MANUFACTURED BY

THE DRAYTON REGULATOR AND INSTRUMENT CO. LTD.

West Drayton, MIDDLESEX.

187

PARTNERSHIPS.

ENGINEERING FIRM (Established Over 40 Years), owing to death, have VACANCY for an EXECUTIVE, practical, technical or commercial. Capital required about £6000.—Reply, CRASTON THOMSON and ALLISON, C.A., 219, St. Vincent-street, Glasgow. P2427 c

EDUCATIONAL

Correspondence Courses

OF PREPARATION FOR THE

Examinations

OF THE
INST. OF CIVIL ENGINEERS,
INST. OF MECHANICAL ENGRS.,
INST. OF STRUCTURAL ENGRS.,
UNIVERSITY OF LONDON, &c.,
ARE PERSONALLY CONDUCTED BY

Mr. Trevor W. Phillips,

B.Sc., Honours, Engineering, London University, Assoc. M. Inst. C.E., A.M.I. Struct. E., M.R.S.I., F.R.S.A., Chartered Civil Engineer, &c.

For full particulars and advice apply to:—
36, DALE STREET, LIVERPOOL.
LONDON OFFICE:—65, CHANCERY LANE, W.C. 2.

FOR SALE, THEODOLITES, DRAWING INSTRUMENTS, SECOND-HAND. CLARKSON'S, 338, High Holborn, W.C. (Opposite Gray's Inn-road).

FOR SALE, LEVELS, DRAWING INSTRUMENTS, SECOND-HAND. CLARKSON'S, 338, High Holborn, W.C. (Opposite Gray's Inn-road). EX.

EDUCATIONAL

AUTHORITATIVE TRAINING.

For 14 years The T.I.G.B. has been serving engineers in two valuable ways, as follows:—

(1) Through Correspondence Courses designed for the professional examinations, including A.M. Inst. C.E., A.M.I. Mech. E., Grad.I.E.E., etc., also for B.Sc., C. & G., G.P.O., etc.

(2) Through Correspondence Courses designed to cover comprehensively all sections and branches of engineering; examples in the Civil and Mechanical Fields are:—

Road Construction	Steam and Internal Combustion Engineering
Structural Engineering	Machine Design
Concrete Construction	Engineering Metallurgy
Sanitary Engineering	Refrigeration
Building Construction	Gas & Chemical Engineering
Specifications and Quantities	Railway Signalling

The services of over 70 Specialists have been utilised in the compilation of The T.I.G.B. Courses, and many of these men are recognised authorities in their respective branches of engineering.

Write to-day for "The Engineer's Guide to Success"—140 pages—containing the widest choice of engineering courses in the world. The T.I.G.B. guarantees training until successful for the one fee.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN,
76, Temple Bar House, London, E.C. 4.

(Founded 1917 18,000 Successes).

MISCELLANEOUS

WANTED, MILL for Rolling Light Rails from Old heavy sections, together with all necessary accessories. Second-hand plant preferred. Also REQUIRED, an EXPERT accustomed to this work.—JOHN F. WAKE, Darlington. P2429 i

A WELL-ESTABLISHED FIRM of Commercial Building Contractors, with extensive connection in London and the Home Counties, has FUNDS AVAILABLE to assist clients in the Erection of Buildings in these areas. Principals only are invited to communicate with the Contractors. Strict confidence observed.—Address, 8526, The Engineer Office. 8526

ENGINEERING FIRM REQUIRED to MANUFACTURE SMALL PARTS of MACHINE hitherto imported. Quantities not very large. Would also suit Instrument Makers. In or near London essential. —Address, 8537, The Engineer Office. 8537 i

LOOSE-LEAF METAL ACTIONS FOR POCKET BOOKS.—Advertisers, who are large manufacturers of loose-leaf books, Desire to Get into Communication with Inventors or Engineers with a view to considering the Purchase of New Patent or important Improvements in present Metal Movements.—Address in first place for further details, P2432, The Engineer Office. P2432 i

TO ENGINEERS.—ADVERTISERS DESIRE to GET IN TOUCH with a FIRM, well equipped and of good financial standing, with a view to MANUFACTURING SPECIALITIES in great demand. —Address, P2409, The Engineer Office. P2409 i

ENGINEERS—IMPORTANT NOTICE.

The 19th Edition of "ENGINEERING OPPORTUNITIES" is now ready for distribution. This is not merely a pamphlet, but a 200-page book of unique reference that you cannot well afford to miss. By reading it you will know us, our work, our aims and how we can alter your entire outlook and earning power, whatever your age or experience. Among other things, the Handbook shows the easiest way of preparing for B.Sc., A.M.I.Mech. E., I.E.E., G.P.O., etc. Exams., outlines Modern Home-Study Courses in all branches of Civil, Mech., Elec., Motor, Aero., Radio and "Talkie" Engineering, and explains the unique advantages of our Employment Department. "ENGINEERING OPPORTUNITIES" has shown the way to better things to over 120,000 of your fellows. Send for your copy to-day —FREE and without obligation.

BRITISH INSTITUTE OF ENGINEERING TECHNOLOGY,
22, Shakespeare House, 29-31, OXFORD STREET, LONDON, W.1. P2389 i

FOR SALE.

BOILERS, TANKS and AIR RECEIVERS.

New, several 11ft. long by 5ft., Recs. 80 lb. W.P.
Lancashire Boiler, 26ft. by 7ft., 80 lb. W.P.
Cornish Boiler (1915), 24ft. by 6ft. 6in., 80 lb. W.P.
TANKS (Boiler Shells), 30ft. by 8ft., extra heavy.
Ditto 30ft. by 7ft.

H. & T. DANKS (Netherton), LTD.
Boilermakers and Engineers, Netherton, DUDLEY. 5840 a

FOR SALE, ONE 8-Ton PORTAL ELECTRIC JIB CRANE, arranged for hoisting (max. radius 105ft.), slewing, luffing, and travelling motions. Particulars and inspection upon application.—Address, 8547, The Engineer Office. 8547 a

FOR SALE.
10in. by 12in. VERTICAL THREE-THROW RAM PUMP, belt drive, by Fearns, capacity 25,000 gallons per hour.
6in. by 12in. HORIZONTAL BELT-DRIVEN QUADRUPLE-ACTING PUMP, by Lee, Howl and Co., capacity 13,000 gallons per hour.
30 B.H.P. VERTICAL CRUDE OIL ENGINE, by Marshalls.
7in. CENTRIFUGAL PUMP, with extended bedplate, by Gwynnes.
12in. "Acme" HACK SAWING MACHINE, by Wicksteed.
70 H.P., 440-Volt D.C. MOTOR, by Siemens, 574 r.p.m., compound wound.
50 H.P. Series-wound ELECTRIC MOTOR, 500 volts D.C., speed 530 r.p.m., with Drum Type Controller.
16 N.H.P. LOCO. TYPE BOILER, by Robey and Co., 100 lb. w.p.
20ft. by 9ft. PETROL STORAGE TANKS.
STANLEY ENGINEERING CO., Bath. Telephone, 4294 (2 lines).

"600"

"EMPEROR" BRICKMAKING PRESS, by Sutcliffe-Speakman & Co., to make standard size bricks; with Accessories; belt drive; capacity 10,000 bricks per day; reconditioned and overhauled; in first-class condition.

TWO 300 B.H.P. four-cylinder HEAVY OIL ENGINES, by Vickers-Petter; speeds 250 r.p.m.; with Accessories; in condition practically equal to New.

TWO 25 K.W. Allen's D.C. Oil Engine-driven GENERATING SETS; can be supplied for either 220 or 440 volts supply; seen running if required; in first-class condition.

Further particulars and lowest prices of any of the above items sent gladly.

GEO. COHEN, SONS & CO., LTD.,
600, COMMERCIAL ROAD EAST, LONDON, E. 14.
Tel.: East 6060. Telegrams: "Cohorn," London.

For continuation of For Sale Advertisements see page 4

To Engineers, Founders, Manufacturers.
Fine site of nearly 3 acres on Arterial Road with Foundry and Workshops and own Rail Sidings into the premises. Modern Offices, Warehouse and Workrooms. Central heating.
CHARLES A. TRICKS & SON, Auctioneers, St. Nicholas Street, BRISTOL.

A Seven-Day Journal

London's Water.

THE twenty-sixth annual report of Sir Alexander Houston, Director of Water Examination to the Metropolitan Water Board, has been published since our last issue went to press. The report, in general, gives the results of the chemical and bacteriological tests made on the water supplies of London during 1931. Particular interest attaches to that portion which deals with the outbreak of paratyphoid fever at Epping in February and March, 1931. From zero the number of cases rose to 115 in three weeks and then subsided. The trouble was traced to the consumption of infected milk, and therefore did not directly involve any question of water supply. Nevertheless, the Water Board was anxiously concerned in the outbreak. Part of the sewage from Epping, after treatment on land, discharges into Cobbins Brook, which joins the Lee at Waltham Abbey above all the Board's intakes from the river Lee. On February 18th a sample of the sewage effluent was examined, and it was discovered that paratyphoid bacteria were being discharged into Cobbins Brook at the rate of over 33 thousand million per day. Immediate steps were taken to reinforce the safeguards already protecting the water consumers in the East End of London. By February 26th the whole of Cobbins Brook was being sterilised by means of a chlorinating plant, which dosed the brook water with chlorine at the rate of about 2·5 parts per million. In addition, the filtered water from the Lee Bridge Works and the Ferry-lane Works was sterilised. The treatment was continued to and beyond the end of the year. Although there was only one case of paratyphoid reported from Epping after March 14th, 1931, paratyphoid organisms continued to be found in the Epping sewage at the end of the year. This disquieting fact may possibly be attributed to the residence at Epping of a number of "carriers" of the disease.

Cast Iron Research.

THE quarterly bulletin of the British Cast Iron Research Association has just appeared. It is concerned principally with testing, and a report by Mr. J. G. Pearce on the influence of the shape of the tensile test bar is of particular interest. Mr. Pearce states that in America and Germany a definite move has taken place towards the use of a shorter test bar. He prepared a series of bars cast in good engineering iron. Fifteen test pieces were made in each of three series. In the first of these series a standard gauge length of 2in. was used in each of five grip lengths from 3in. to 1in. In the second series a gauge length of 1in. in each of the same five grip lengths was employed, and in the third there was no gauge length, the standard shoulder radii meeting in the centre of the test piece and giving a bar diminishing towards the centre without a parallel length. All the bars were machined to the standard diameter 0·798in. The illuminating conclusions were reached that there is no regular variation in strength with grip length and that strength is unaffected by grip length; there is no regular variation in strength with gauge length and strength is apparently unaffected by gauge length. Mr. Pearce states that "while too much reliance cannot be placed on a series of tests based on one iron and a limited number of grip lengths and gauge lengths, the results suggest that the tensile strength of cast iron is independent of grip length and gauge length, and, consequently, that the latter could with advantage be modified in the standard test piece. The bulletin also includes a report on the activities of the Association, mostly concerned with the financial aspect, which has, of course, been much influenced by industrial depression, and an alteration in the terms by which a Government grant is received. This alteration in the terms has made it necessary for the Association to call for greater support from the industry itself if its activities are not to be hindered.

The Loss of the Georges Philippar.

THE French shipping company, Des Services Contractuel des Messageries Maritimes, has suffered a severe blow in the loss of its recently completed million-pound motor passenger liner "Georges Philippar," which was destroyed by fire in the Gulf of Aden on Monday, May 16th. Although full details of the disaster are still awaited, it is feared that a serious loss of life may have taken place. The liner was returning from her maiden voyage to the East, and the fire apparently began in the early morning hours. In response to wireless calls for help two Liverpool steamers, the "Mahsud" and the "Contractor," and the Soviet tanker "Sovietskaia Neft" were quickly alongside the burning ship and took off passengers and crew, while the P. and O. liner "Kaiser-I-Hind" and the Orient liner "Otranto," as well as the "Hakone Maru," also gave aid in the search for boats. Out of an estimated total of 767 persons, some 676 passengers and crew have so far been accounted for. The "Georges Philippar," which at the time of writing was still burning and adrift, was built by the Ateliers et Chantiers de la Loire at St. Nazaire, and was equipped with twin-screw two-stroke Sulzer engines built by the Compagnie de Construction Mécanique Procédés Sulzer, of Paris. She had a measurement of 17,000 gross tons and an overall length of 565ft., with a beam of 68ft. 2in. and a depth of 47ft. The propelling machinery was designed for an output of about 11,600 S.H.P., with a service speed of about 17 knots. The hull and superstructure embodied the latest practice with regard to safety equipment, but the nature of the fire, whatever was the cause, would appear to have been such that it was not possible to cope with it, and the ship had to be quickly abandoned. She was launched in November last, was commissioned at the end of last year, and left Marseilles on her maiden voyage to Yokohama on February 26th.

Telephone Apparatus for Marine Wireless Stations.

FOR the purpose of testing the possibilities of wireless communication on ships in home waters, the marine wireless stations round the coast of the British Isles are to be fitted with wireless telephone apparatus. Messages transmitted by telephone from ships to these coast stations will be conveyed by telegram to their destination on land, whilst telegrams sent to ships equipped for this service will be telephoned from the coast stations out to sea. Vessels which have not hitherto been fitted with wireless apparatus, such as those engaged in the coastal trade and the smaller classes of ships, will be able to take advantage of wireless communication by means of equipment which can be operated by the ship's own *personnel* at a very moderate cost. If the service proves successful during the period of trial, the General Post Office, which is obtaining the wireless apparatus for the stations round the coast from the Marconi International Marine Communication Company, will arrange for its continuance on a permanent basis. For use on board ship the Marconi engineers have designed two types of small and compact telephone installations, one of 300 watts power and one of 60 watts. By keeping in close touch with their owners, coasting vessels can probably save much time and money when circumstances lead to change of instructions in regard to ports of call. Wireless telephone installations already exist at the Wick, Fishguard, and Humber coastal wireless stations.

A New Nelson Liner.

ON Saturday morning last, May 14th, the newly completed motor liner "Highland Patriot," the latest addition to the Nelson Line, was formally handed over by her builders, Harland and Wolff, Ltd., of Belfast. She left for London the same day, and after a smooth and uneventful voyage in somewhat hazy weather, arrived at Gravesend on Monday evening, proceeding later to the Albert Dock. Leading officials of the owners and builders, together with representatives of shipping and marine engineering interests, made the voyage round from Belfast Lough, and in very pleasant conditions. Like the other four motor ships of the Nelson fleet, the "Highland Patriot" has been built to the specification of Mr. A. R. T. Woods, the managing director of the Nelson Line, and embodies all the most modern features of a refrigerated cargo ship, with excellent accommodation for first-class, intermediate-class, and emigrant class passengers. She has a length of 520ft. between perpendiculars, a breadth of 69ft., and a depth to the upper deck of 35ft. 9in., with a loaded draught of about 28ft. Her measurement is 14,157 gross tons, and she is propelled by twin-screw, eight-cylinder, Harland-B. & W., double-acting, four-stroke engines, with a total designed output of 9600 B.H.P. at 105 r.p.m. Most of the auxiliary machinery is electrically operated, and for this purpose, and for lighting, four 200-kW Harland-B. & W. oil engine driven generator sets are installed. The refrigerating installation is of particular interest, as it comprises two sets of Crossley-Premier *vis-à-vis* oil engines coupled to Hall ammonia compressors. The whole of the refrigerating equipment was installed by J. and E. Hall, Ltd., of Dartford, and is designed to deal with about 616,000 cubic feet of insulated space, the brine control system being arranged for either chilled or frozen meat or fruit cargoes.

American Unemployment Relief Scheme.

ON Friday, May 13th, it was announced by President Hoover that the establishment of an unemployment relief scheme had been decided upon, and that it would utilise the resources of the Reconstruction Finance Corporation, of which the borrowing powers would be increased by 1,500,000 dollars. The programme outlined by Mr. Hoover contemplates the provision of machinery for the restoration of normal occupations rather than the creation of works of an artificial character. It is claimed that "without entering the field of industrial or public expansion, there are a large number of economically sound, self-supporting projects which are of a constructive replacement character that would unquestionably be carried forward were it not for the present situation existing in the capital markets and the inadequate functioning of credit machinery in the country." Such projects exist, it is said, both in the field of public authorities and of industry. There would appear to be no dearth of capital for productive purposes that have been held in abeyance, and the problem is that of making existing capital available, and of stimulating its use for constructive activities. In order to do this President Hoover proposes to increase the borrowing powers of the Reconstruction Finance Corporation as stated above, the total amount of funds for relief purposes being probably limited to 250,000,000 to 300,000,000 dollars. The Corporation would assist States by underwriting State loans or by lending money to them direct.

The Late Captain Robert Dollar.

IT is with regret that we learn of the recent death of Captain Robert Dollar, which took place at his Californian home at San Rafael. Captain Dollar, who was known internationally as the founder and president of the Dollar Steamship Company, was in his eighty-eighth year at the time of his death. He was a Falkirk boy and was born in 1844. After spending some time in a Canadian lumber camp he went to America in 1856, and was naturalised in 1888. From small beginnings, which started with a ship of 300 tons, he built up a Pacific shipping trade which in 1901 was extended to China by the sailing of the "Arab," a 6500-ton steamer. In 1929 he purchased from the United States Shipping Board the fleet of "President" liners and later founded the Dollar Line. Among the ships of that line are the leading steamers and motor vessels in the Pacific trade, whilst the same line also has important interests in trade with Alaska and with other countries. In his later years Captain Robert Dollar became one of America's largest shipowners, with wide interests in American and Canadian lumber companies and in international banking concerns. He was made a freeman of his native town of Falkirk, and similar honours were conferred upon him by the cities of Boston, New York, and Shanghai, in recognition of his work and his charitable interests.

Smoke Abatement Progress.

IN the newly issued *Journal* of the National Smoke Abatement Society the question as to whether the pollution of the air of our towns and cities by smoke is decreasing is ably discussed in an article which makes reference to a review of the subject by Mr. J. B. C. Kershaw, which appeared in THE ENGINEER of February 12th last. Following the interpretation which many have given to a paragraph in the last report of the Department of Scientific and Industrial Research regarding the absence of improvement in the atmosphere of London during the last ten years, an attempt has now been made to analyse further the figures given yearly by that authority. Figures are produced which show that for the three-year period of 1929 to 1931, compared with the period 1926 to 1928, there has been a reduction in the total deposits at the stations observed throughout the country of no less than 16·6 per cent., while decreases of 24·5 and 18·9 per cent. in the deposits of tar and sulphates have been recorded. The tar figures, it is pointed out, are of particular interest, as that particular product is principally derived from the smoke of domestic fires. There seems little doubt that, on the whole, a gradual but certain lessening of the smoke nuisance is being achieved. Certain factors which must be taken into account in examining the records published are the effects of industrial depression in lowering the totals, the effects of approximately two million houses erected since the war, which tend to increase the total, and, finally, the variations caused by the rapid industrialisation of certain areas, especially in the South. The necessity for more observing stations and a greater number of gauges in each area in order that mean and not maximum or minimum deposits may be ascertained is pointed out.

William Beardmore and Co., Ltd.

AT the annual meeting of William Beardmore and Co., Ltd., which was held in London on Wednesday last, May 18th, Mr. H. A. Reincke, the chairman and managing director, sounded an inspiring note, although having to report under the very difficult trading conditions and general lack of orders an increased trading loss. Describing the activities of the various works, Mr. Reincke went on to say that at Parkhead a battery of the most modern gas machines had been laid down, which had effected considerable economy in gas production, and had put the Parkhead works in a good position to take full advantage of any improvement in trade. In the high-speed oil engine department successes had been recorded in both rail and road transport, and new models were being introduced. An increasing number of inquiries had been received. The Dalmuir works had been principally employed on naval and mercantile marine work, but there had been but few new orders. In general, further economies had been effected in all departments, but the efforts made could not be rewarded unless means beyond the control of industry were found to engender an effective demand for goods and services in the export markets of the world. The Beardmore works were among some of the finest and best equipped of their kind in Scotland, and in any revival of the Scottish steel industry they must play their part. Mr. Reincke paid a tribute to all those who, with their experience and knowledge of industry, were helping him in a task which, he said, was no less inspiring because it was indeed a difficult one.

The Determination of Worm Gear Contacts.

By STUART MIALL, B.Sc. (Eng.).

THE type of worm gearing to be dealt with in this article is the parallel type, in which the worm threads are spaced along a base cylinder and the working faces are generated by the motion of a straight line. Two special cases of this general type are the straight-sided, or involute, type, and the F J type, both widely manufactured at the present time. The behaviour of such gearing lends itself to investigation by cartesian methods, and the following is an account of the derivation and use of the necessary equations.

The diagrams relate to right-handed worms in some instances and left-handed worms in others, while, for convenience of treatment in the first instance, there will be continuous and uniform action in all planes.

The object of the present investigation is to determine in each sectional plane—

(1) The worm profile.
(2) The corresponding path of the point of contact.
(3) A method for obtaining the wheel profile.

It is well known that fairly accurate sections of worms may be obtained graphically, but that the method shown in Fig. 2 of drawing normals to such a section A B in order to determine the path of contact a_1, a_2, a_3, a_4, &c., is inherently unreliable. Particularly must there be unreliability for a section to which the trace X′X″ of the worm pitch plane is itself one of the normals. The path of contact will not then, of necessity, pass through the pitch point P, but may lie wholly to one side, as shown by the full line $a\,a'$ in Fig. 3. A small movement of the pitch plane up or down has a very pronounced effect upon the form of the contact path causing it to break up into two distinct paths, one above and one below the old pitch line. As these new paths are, in part, infinitely distant from the pitch point, their figures are singularly difficult to determine, even approximately, by purely graphical methods. Fig. 8 shows at p and p' the kind of paths obtained by raising the pitch plane and at q and q' the kind of paths obtained by lowering the pitch plane. The dotted lines in Fig. 3 show the effect of larger movements in the pitch plane.

While somewhat laborious in its development, the method of finding and plotting the cartesian equations to the paths of contact is fairly simple to employ in many practical instances, and the author, since systemizing the calculations, has been able to determine fairly rapidly from a knowledge of leading particulars what must be the behaviour of gears in a number of particular instances.

(1) DERIVATION OF EQUATION TO WORM PROFILE.

If a straight line be moved in such a way that the points on it describe either right or left-handed helices, all of the same pitch, then the surface so swept out by its motion will form a working face of a worm belonging to the general type. If one point in the line generates a helix whose enveloping cylinder is of infinitesimal diameter, the worm is of the straight-sided family. If the skew angle between the axis of the helices and the generating line is equal to the spiral angle of the smallest helix, the worm is of the F J family.

Figs. 4 and 5 show the method of generation in which the smallest helix envelops a cylinder of radius r, in which all the helices have a lead of p, and in which the skew angle between the generating line and the common axis of the helices is $90°-\varphi$. A_1P_1, A_2P_2 are two positions of the generating line, A_1A_2 being a portion of the smallest helix and P_1P_2 a portion of any other helix. The initial position of the generating line is A_1P_1, where it is parallel to the X Y plane, with its foot A_1 on the Z Z axis. It is moved in the direction of the arrow into position A_2P_2, the interval between the two positions corresponding to a rotation of θ radians and an advance of a.

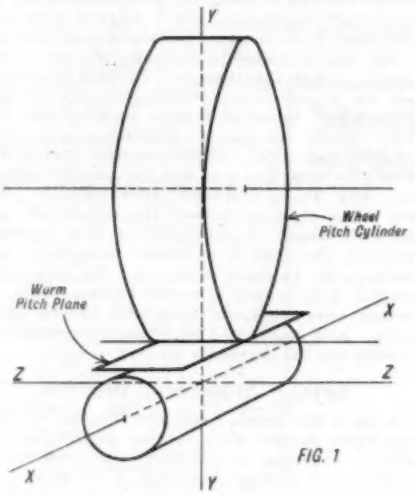


FIG. 1

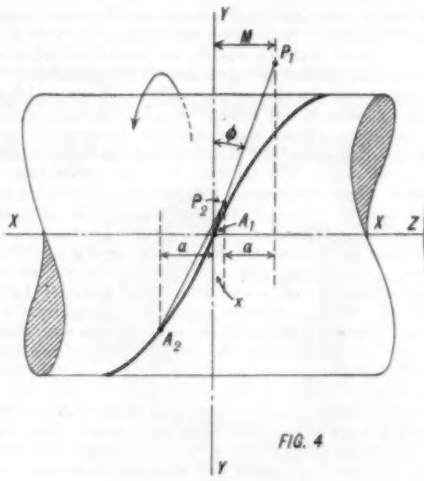


FIG. 4

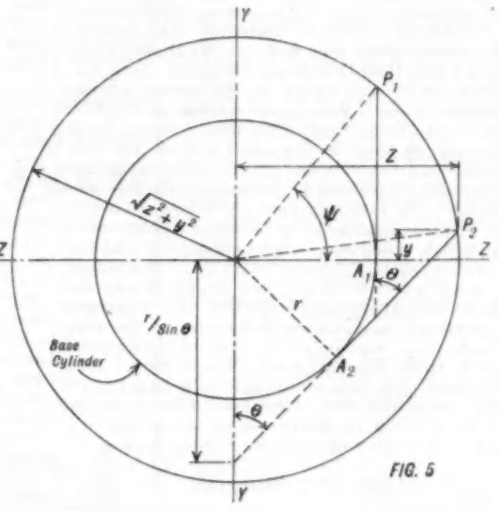


FIG. 5

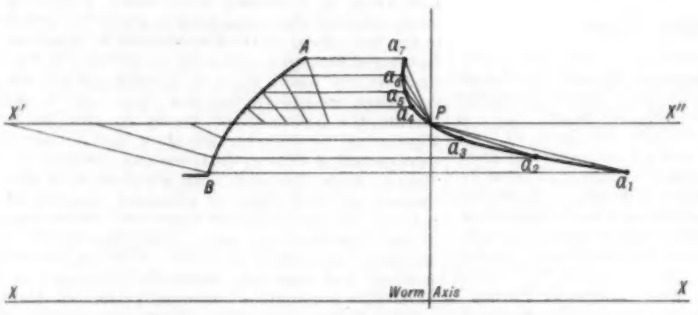


FIG. 2

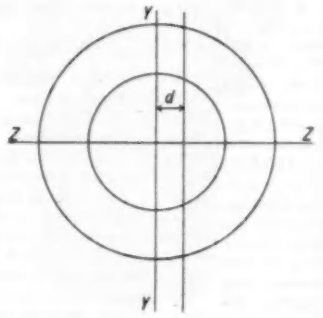


FIG. 6

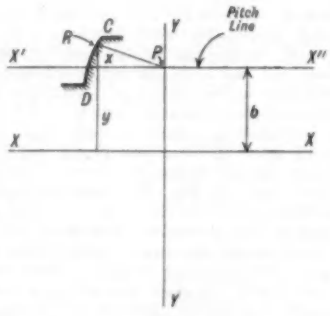


FIG. 7

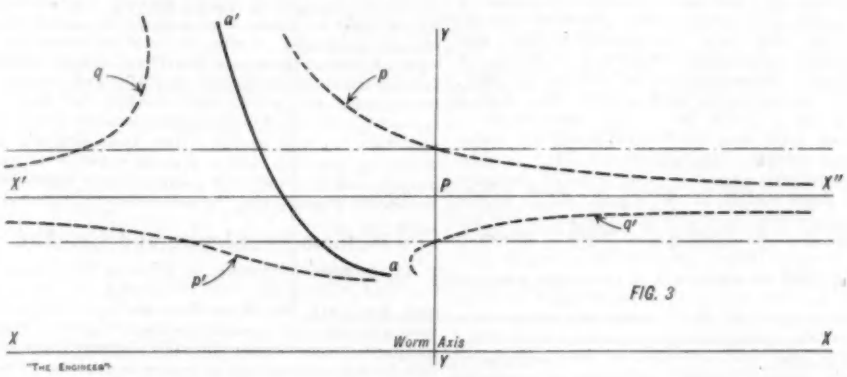


FIG. 3

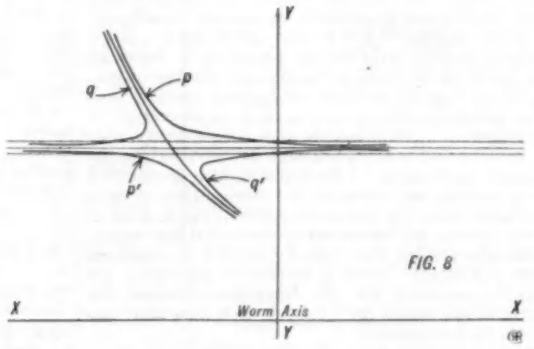


FIG. 8

positive values of x have been measured to the left instead of the right of the Y Z plane.

The axis X X is taken to coincide with the worm axis, while the axis Y Y coincides with the perpendicular between the worm axis and the wheel axis. The wheel axis is contained in the Y Z plane, while the worm axis lies along the inter-section of the X Y and the X Z planes. The pitch plane of the worm is parallel to the X Z plane, and tangential to the pitch cylinder of the wheel, while the line of contact between pitch plane and pitch cylinder passes perpendicularly through the Y Y axis in the Y Z plane, and is therefore parallel to the Z Z axis. Fig. 1 shows in a perspective view how the coordinates lie with respect to the axes and pitch surfaces of worm and wheel.

In a longitudinal section made by the plane X Y, and in sections made by other planes parallel to the X Y plane, the action of a properly constructed gear will appear to be that of a rack and pinion. Except in the X Y plane, both rack and pinion teeth will be unsymmetrical, and of neither involute nor cycloidal formation. If, however, the wheel hobbing process has been correctly carried out, the profiles revealed by sectioning will be conjugate to one another, and

$$a=\frac{\theta}{2\pi}\,p$$

$$\sin\theta=\frac{z}{\sqrt{z^2+\left(y+\frac{r}{\sin\theta}\right)^2}}$$

$$\sin^2\theta=\frac{z^2}{z^2+y^2+\frac{2\,r_1 y}{\sin\theta}+\frac{r^2}{\sin^2\theta}}$$

$$\therefore\ (z^2+y^2)\sin^2\theta+2\,r\,y\sin\theta+(r^2-z^2)=0$$

From which :—

$$\sin\theta=\frac{-2\,r\,y\pm\sqrt{4\,r^2\,y^2-4\,(z^2+y^2)\,(r^2-z^2)}}{2\,(z^2+y^2)}$$

When $z=r$, $\sin\theta$ should $=0$. Therefore the $+$ sign must be taken with the radical. Hence :—

$$a=\frac{p}{2\pi}\sin^{-1}\left\{\frac{-2\,r\,y+\sqrt{4\,r^2\,y^2-4\,(z^2+y^2)\,(r^2-z^2)}}{2\,(z^2+y^2)}\right\}$$

$$=\frac{p}{2\pi}\sin^{-1}\left\{\frac{-r\,y+z\sqrt{z^2+y^2-r^2}}{z^2+y^2}\right\}$$

From Fig. 5 :—

$$M = \sqrt{z^2+y^2}\,\tan\varphi\,\sin\psi$$

$$x = M - a = \sqrt{z^2+y^2}\,\frac{\tan\varphi}{\operatorname{cosec}\psi} - \frac{p}{2\pi}\sin^{-1}\left\{\frac{-ry+z\sqrt{z^2+y^2-r^2}}{z^2+y^2}\right\}$$

$$\frac{1}{\operatorname{cosec}\psi} = \sqrt{1-\frac{r^2}{z^2+y^2}} = \frac{\sqrt{z^2+y^2-r^2}}{\sqrt{z^2+y^2}}$$

Therefore the equation to the surface of the general type of worm is :—

$$x = \sqrt{z^2+y^2-r^2}\,\tan\varphi - \frac{p}{2\pi}\sin^{-1}\left\{\frac{-ry+z\sqrt{z^2+y^2-r^2}}{z^2+y^2}\right\}$$

The equation of the intersection of this surface with the plane $z=d$—see Fig. 6—is found by putting d for z in the above equation.

It is :—

$$x = \sqrt{y^2+d^2-r^2}\,\tan\varphi - \frac{p}{2\pi}\sin^{-1}\left\{\frac{-ry+d\sqrt{y^2+d^2-r^2}}{y^2+d^2}\right\}$$

For the straight-sided or involute worm $r=0$ and φ is the pressure angle.

The equation of the surface is :—

$$x = \sqrt{z^2+y^2}\,\tan\varphi - \frac{p}{2\pi}\sin^{-1}\left\{\frac{z}{\sqrt{z^2+y^2}}\right\}$$

The equation of section is :—

$$x = \sqrt{d^2+y^2}\,\tan\varphi - \frac{p}{2\pi}\sin^{-1}\left\{\frac{d}{\sqrt{d^2+y^2}}\right\}$$

The equation of section for the central plane ($d=0$) is :—

$$x = y\tan\varphi,$$

and plainly this gives a straight line profile.

For the F J worm $\tan\varphi = p/2\pi r$, since φ is now the lead angle of the smallest helix. Hence the equation of the surface is :—

$$x = \frac{p}{2\pi}\left[\frac{\sqrt{y^2+z^2-r^2}}{r} - \sin^{-1}\left\{\frac{-ry+z\sqrt{y^2+z^2-r^2}}{z^2+y^2}\right\}\right]$$

The equation of section is :—

$$x = \frac{p}{2\pi}\left[\frac{\sqrt{y^2+d^2-r^2}}{r} - \sin^{-1}\left\{\frac{-ry+d\sqrt{y^2+d^2-r^2}}{d^2+y^2}\right\}\right]$$

The equation of section for the plane $z=r$ is :—

$$x = \frac{p}{2\pi}\left[\frac{y}{r}\right] = y\tan\varphi$$

and this also is a straight line profile.

Plane sections are more easily obtained by a drawing board method—see Fig. 9—than by plotting the foregoing equations. The equations, however, are necessary to the furtherance of the investigation.

(2) DERIVATION OF EQUATION TO PATH OF CONTACT.

In Fig. 7 is shown a section C D of a worm in any position with respect to the pitch point P. A particular normal R P to the section at R passes through the pitch point, and R is a point on the contact path. It is desired to obtain the locus, with respect to the axes, of point R as C D moves from right to left.

Let $x=f(y)$ be the equation of the section. Then $\left(\frac{dx}{dy}\right)_R$ will be the tangent of the angle, which the normal makes with X X or X′X″, and, if x_R and y_R be the coordinates of point R, then —

$$x_R = \frac{y_R - b}{\left(\frac{dx}{dy}\right)_R}$$

is the condition to be satisfied if uniform action is desired. Here b is the perpendicular distance between the axis of the worm and the pitch plane.

The equation of section of the general type of worm is given above. By differentiation :—

$$\frac{dx}{dy} = \frac{y\tan\varphi}{\sqrt{y^2+d^2-r^2}} - \frac{p}{2\pi}\left\{\frac{1}{\sqrt{1-\left(\frac{-ry+d\sqrt{y^2+d^2-r^2}}{d^2+y^2}\right)^2}}\right\} \times \frac{d}{dy}\left\{\frac{-ry+d\sqrt{y^2+d^2-r^2}}{d^2+y^2}\right\}$$

Now

$$\frac{d}{dy}\left\{\frac{-ry+d\sqrt{y^2+d^2-r^2}}{d^2+y^2}\right\} = \frac{(y^2+d^2)\left[\frac{dy}{\sqrt{y^2+d^2-r^2}} - r\right] - 2y\left[d\sqrt{y^2+d^2-r^2} - ry\right]}{(d^2+y^2)^2}$$

So that :—

$$\frac{dx}{dy} = \frac{y\tan\varphi}{\sqrt{y^2+d^2-r^2}} - \frac{p}{2\pi}\left[\frac{(d^2+y^2)\left(\frac{dy}{\sqrt{y^2+d^2-r^2}} - r\right) - 2y\,(d\sqrt{y^2+d^2-r^2} - ry)}{(d^2+y^2)\sqrt{(d^2+y^2)^2 - (-ry+d\sqrt{y^2+d^2-r^2})^2}}\right]$$

and the equation to the path of contact is :—

$$x = \frac{y-b}{\frac{y\tan\varphi}{\sqrt{y^2+d^2-r^2}} - \frac{p}{2\pi}\left[\frac{(d^2+y^2)\left(\frac{dy}{\sqrt{y^2+d^2-r^2}} - r\right) - 2y\,(d\sqrt{y^2+d^2-r^2} - ry)}{(d^2+y^2)\sqrt{(d^2+y^2)^2 - (-ry+d\sqrt{y^2+d^2-r^2})^2}}\right]}$$

Corresponding equations for the straight-sided and F J worms can be formed by substituting $r=0$ for the first and $\tan\varphi = p/2\pi r$ for the second. In its application to the straight sided worm the equation is fairly easy to plot, and in other applications the work though laborious is not necessarily difficult. In its application to the F J type of worm, however, the equation is awkward by virtue of the fact that certain substitutions lead to indeterminate results.

APPLICATION OF THE FOREGOING EQUATION TO WORMS OF THE F J TYPE.

When Mr. Bostock first brought out the F J worm, the value which b would have had in the above equation was r. An examination of worm sections will readily show that under such circumstances the pitch plane cuts the working face of the worm normally from root to crest along a generating line. This it does only on that side of the worm which is receding from the central or X Y section plane, and no special complications are encountered in plotting the above equation if d be given positive values. If, however, d be given negative values, then the equation becomes quite unplottable, for values of y approaching the value of $y=r$. When $y=r$, and again when $y=\sqrt{r^2-d^2}$—which value y will have on the smallest helix—the value of x becomes indeterminate. The conditions are those obtaining in Figs. 3 and 8. Fortunately, it is possible to locate the indeterminate points themselves, and it can be shown that for $y=r$:—

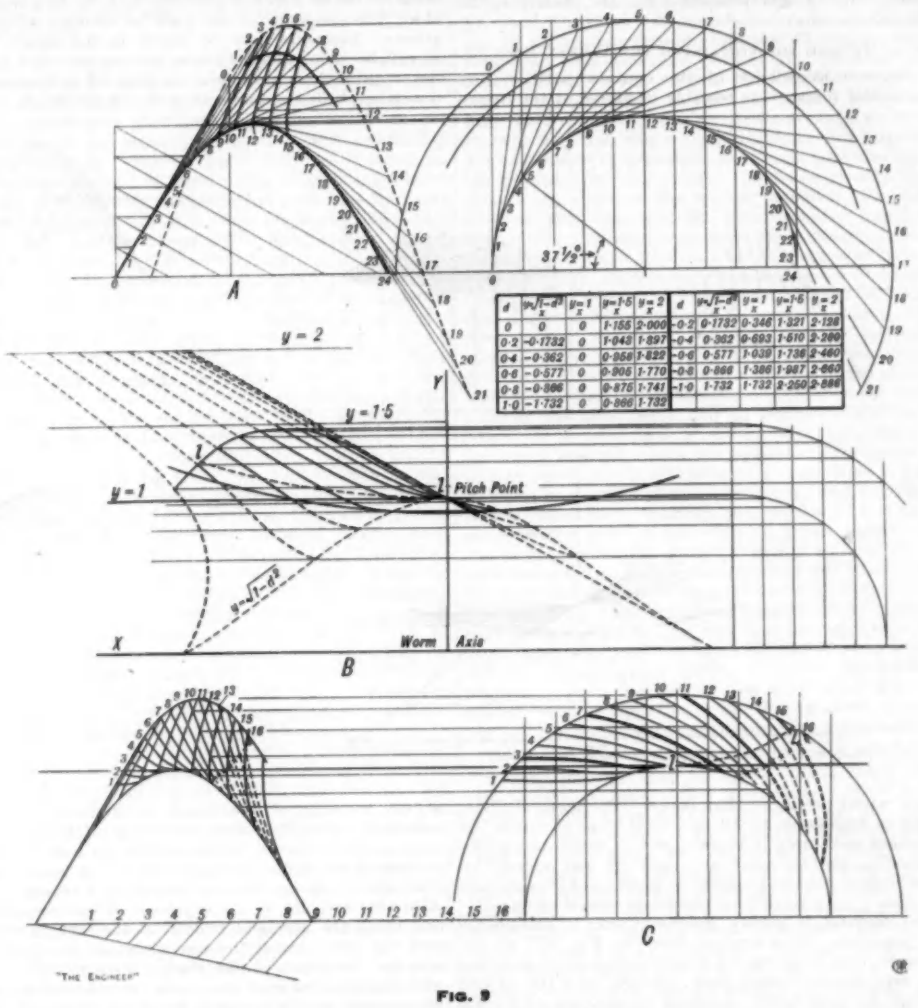
$$x = d\cot\varphi$$

while for $y=\sqrt{r^2-d^2}$:—

$$x = \frac{r}{d}\cot\varphi\,(\sqrt{r^2-d^2} - r)$$

—both very simple results.

The author had occasion to investigate the contact paths of a worm having a base lead angle of 30 deg., is shown on Fig. 9. In this and in other instances it was found sufficient to plot eleven instead of twenty-one paths of contact. For Fig. 9 these are shown at B, while the corresponding sections, graphically obtained, are shown above at A.



d	$y=\sqrt{1-d^2}$ / x	y=1 / x	y=1·5 / x	y=2 / x	d	$y=\sqrt{1-d^2}$ / x	y=1 / x	y=1·5 / x	y=2 / x
0	0	0	1·155	2·000	−0·2	0·1732	0·346	1·321	2·136
0·2	−0·1732	0	1·043	1·897	−0·4	0·362	0·693	1·510	2·200
0·4	−0·362	0	0·958	1·822	−0·6	0·577	1·039	1·736	2·460
0·6	−0·577	0	0·905	1·770	−0·8	0·866	1·386	1·987	2·665
0·8	−0·866	0	0·876	1·741	−1·0	1·732	1·732	2·250	2·886
1·0	−1·732	0	0·866	1·739					

FIG. 9

The equation of section for the plane $z=r$ is :—

$$x = \frac{p}{2\pi}\left[\frac{y}{r}\right] = y\tan\varphi$$

and this also is a straight line profile.

Plane sections are more easily obtained by a drawing board method—see Fig. 9—than by plotting the foregoing equations. The equations, however, are necessary to the furtherance of the investigation.

(2) DERIVATION OF EQUATION TO PATH OF CONTACT.

In Fig. 7 is shown a section C D of a worm in any position with respect to the pitch point P. A particular normal R P to the section at R passes through the pitch point, and R is a point on the contact path. It is desired to obtain the locus, with respect to the axes, of point R as C D moves from right to left.

Let $x=f(y)$ be the equation of the section. Then $\left(\frac{dx}{dy}\right)_R$ will be the tangent of the angle, which the normal makes with X X or X′X″, and, if x_R and y_R be the coordinates of point R, then —

$$x_R = \frac{y_R - b}{\left(\frac{dx}{dy}\right)_R}$$

is the condition to be satisfied if uniform action is desired. Here b is the perpendicular distance between the axis of the worm and the pitch plane.

The equation of section of the general type of worm is given above. By differentiation :—

$$\frac{dx}{dy} = \frac{y\tan\varphi}{\sqrt{y^2+d^2-r^2}} - \frac{p}{2\pi}\left\{\frac{1}{\sqrt{1-\left(\frac{-ry+d\sqrt{y^2+d^2-r^2}}{d^2+y^2}\right)^2}}\right\} \times \frac{d}{dy}\left\{\frac{-ry+d\sqrt{y^2+d^2-r^2}}{d^2+y^2}\right\}$$

Now

$$\frac{d}{dy}\left\{\frac{-ry+d\sqrt{y^2+d^2-r^2}}{d^2+y^2}\right\} = \frac{(y^2+d^2)\left[\frac{dy}{\sqrt{y^2+d^2-r^2}} - r\right] - 2y\left[d\sqrt{y^2+d^2-r^2} - ry\right]}{(d^2+y^2)^2}$$

So that :—

$$\frac{dx}{dy} = \frac{y\tan\varphi}{\sqrt{y^2+d^2-r^2}} - \frac{p}{2\pi}\left[\frac{(d^2+y^2)\left(\frac{dy}{\sqrt{y^2+d^2-r^2}} - r\right) - 2y\,(d\sqrt{y^2+d^2-r^2} - ry)}{(d^2+y^2)\sqrt{(d^2+y^2)^2 - (-ry+d\sqrt{y^2+d^2-r^2})^2}}\right]$$

and the equation to the path of contact is :—

$$x = \frac{y-b}{\frac{y\tan\varphi}{\sqrt{y^2+d^2-r^2}} - \frac{p}{2\pi}\left[\frac{(d^2+y^2)\left(\frac{dy}{\sqrt{y^2+d^2-r^2}} - r\right) - 2y\,(d\sqrt{y^2+d^2-r^2} - ry)}{(d^2+y^2)\sqrt{(d^2+y^2)^2 - (-ry+d\sqrt{y^2+d^2-r^2})^2}}\right]}$$

Corresponding equations for the straight-sided and F J worms can be formed by substituting $r=0$ for the first and $\tan\varphi = p/2\pi r$ for the second. In its application to the straight sided worm the equation is fairly easy to plot, and in other applications the obtaining in several gears of the F J type, and the following was found to be a quick and simple method of setting about the work.

For calculation purposes, all dimensions were divided by the radius r of the base cylinder, the latter therefore being taken as unity in the equation for the path of contact. Points on the contact paths—*i.e.*, values of x—were then determined for $y=\sqrt{1-d^2}$, $y=1$, $y=1\cdot5$, and $y=2$. By electing to do this for every worm, and always choosing section planes at $d=0$, $0\cdot1$, $0\cdot2$, $0\cdot3$, &c., and $-0\cdot1$, $-0\cdot2$, $-0\cdot3$, &c., it was possible to cut out all the variables in the equation, with the exception of the lead angle φ, and so to use a table in which the greater part of the calculations had been done once and for all. When the lead angle φ was given, the slide rule was set at the appropriate value of cot φ, and a new table of values of x was drawn up for the worm in question. The basic table is here shown by itself, while the derived table,

d.	Point 1. $y=\sqrt{1-d^2}$ $x=c_1\cot\varphi$		Point 2. $y=1$ $x=c_2\cot\varphi$	Point 3. $y=1\cdot5$ $x=c_3\cot\varphi$	Point 4. $y=2$ $x=c_4\cot\varphi$
	c_1.	y.	c_2.	c_3.	c_4.
0	0	1·000	0	0·667	1·155
0·1	−0·050	0·995	0	0·633	1·124
0·2	−0·100	0·980	0	0·602	1·096
0·3	−0·154	0·954	0	0·575	1·071
0·4	−0·209	0·917	0	0·553	1·052
0·5	−0·268	0·866	0	0·535	1·035
0·6	−0·333	0·800	0	0·522	1·022
0·7	−0·408	0·714	0	0·512	1·012
0·8	−0·500	0·600	0	0·505	1·005
0·9	−0·627	0·436	0	0·500	1·001
1·0	−1·000	0·000	0	0·500	1·000
−0·1	0·050	0·995	0·100	0·713	1·190
−0·2	0·100	0·980	0·200	0·763	1·230
−0·3	0·154	0·954	0·300	0·816	1·271
−0·4	0·209	0·917	0·400	0·871	1·318
−0·5	0·268	0·866	0·500	0·936	1·369
−0·6	0·333	0·800	0·600	1·003	1·421
−0·7	0·408	0·714	0·700	1·069	1·479
−0·8	0·500	0·600	0·800	1·148	1·537
−0·9	0·627	0·436	0·900	1·218	1·602
−1·0	1·000	0·000	1·000	1·300	1·667

By copying A on a sheet of tracing paper, and moving it step by step across B, with the worm axis lines on both drawings in perfect coincidence, successive positions of the line of contact between worm and wheel were drawn across diagram A. When these lines were projected on to the Y Z plane the result shown in Fig. 9c was obtained.

To investigate the effect of altering b in the equation, the best method is to draw the contact paths, as at B, for $b=r=1$, and then, for $y=2\cdot0$, $1\cdot5$, $1\cdot25$, and other suitably chosen values, to tabulate the measured values of x. If b is $1\cdot3$, say, all the tabulated values are to be multiplied by the ratio

$\frac{y-1\cdot3}{y-1}$ and replotted. Fig. 10 shows what a remarkable transformation is effected by raising the pitch plane of the worm in Fig. 9 by 0·1375. Fig. 11 is for a straight-sided worm of the same lead angle, and with a pressure angle chosen to make the worm resemble the F J worm of Fig. 10 as closely as possible. It will be seen that the action of the two gears is very similar as far as can be judged from diagrams of this kind. Modern gears of the F J type are produced to give a value of b/r appreciably greater than unity, since longer contact lines are plainly to be secured thereby.

(3) A Method for Obtaining the Wheel Profile.

From a knowledge of the contact path in any particular plane, it is possible to arrive at the necessary wheel profile in that plane. The method given here is applicable to all gear problems in which the contact path only is known, and in which the corresponding profiles must be found. It was devised by the author for the problem in hand, and though new to him it may have been placed on record previously. The method is purely graphical and a planimeter is required. It is applied first—in Fig. 12—to the simpler task of obtaining a rack section corresponding to any given contact path, though here the profile would be most easily obtained by plotting its $d\,x/d\,y$ against y because the x of a point whose ordinate is y will simply be the area below the y, $d\,x/d\,y$ curve up to the point y, and a planimeter will give this at once.

The given contact path a, b, c, d, &c., is drawn on one side of the paper and horizontal lines parallel to X X and equidistantly spaced are drawn right across the sheet to cut the contact path in points a, b, c, d, &c. Points a, b, c, d, &c., are joined to the pitch point P, and these joining lines represent the successive positions of the common normal to the curves under working conditions. They mark equal intervals of the Y component of the motion of the point of contact.

Now the path of contact is fixed relative to the axes of worm and wheel, but the corresponding section profile is not. As the latter advances towards the left, the point of contact moves along the path of contact, occupying successively the positions a, b, c, d, &c. To make the construction as simple as possible, it is supposed that the motion is such as to cause the point of contact to take equal intervals of time to describe the distances $a\,b$, $b\,c$, $c\,d$, &c. This is an artificial motion because under working conditions such uniformity cannot occur. Then, relative to the axes of worm and wheel, the motion of the point of contact at the points a, b, c, d, &c., will be along the tangents to the path of contact at these points. Tangents may be drawn in the figure, but it will be seen presently that the construction does not require their presence. In Fig. 12 a tangent is drawn at d for the purpose of the explanation. The actual velocity of the point of contact, *i.e.*, the velocity, under the assumed motion, relative to the axes, is proportional to the intercepts made by the parallel lines on the tangents, because it is supposed that this velocity has a constant Y component. Also this velocity is a compound of two velocities, one being the assumed motion of the section profile and the other being the movement of the point of contact over that profile itself. Because the point of contact moves over the profile, it must everywhere be moving at right angles to the normals of that profile, and so the velocity component relative to the section is obtained by drawing lines at right angles to the normals P a, P b, P c, &c., and completing the parallelograms of velocities at a, b, c, &c. It is the component relative to the section that is of especial interest here, because if this velocity is applied to a point so that it moves in a fixed plane, it will compel the point to generate the unknown profile. The generating velocity is variable, both in magnitude and direction, but its Y component remains constant, and hence the Y of this point increases in proportion to time. The Y velocity and the X velocity can be plotted for successive values of y when graphs like those in the central figure of Fig. 12 will be obtained. Because the y of the generating point is proportional to time, the areas enclosed between the velocity curves and the Y axis up to any point A are proportional to the values x and y of the profile at the value of y determined by the horizontal through A. Hence, by determining with a planimeter the ratio of these areas from point to point, the x of any point on the profile can be found from the relationship it bears to the y.

This method is seen to be applicable when wheel teeth profiles are to be found. The profile, however, is constrained to move about a centre, and not in one fixed direction, and so, instead of talking about X and Y velocities it is necessary to speak of circumferential—or angular—and radial velocities when following the movements of the generating point. In Fig. 13 the profile is compelled to revolve about the centre C, so that the radial component of the velocity of the point of contact is constant. Parallelograms of velocity are completed at many points along the path of contact, as before. These points, however, need not correspond with equal increments of the radius in the way that in Fig. 12 they corresponded with equal increments of y, for here the construction is not facilitated by any such correspondence. The points are chosen at random, but the radial velocity vector is, nevertheless, drawn to the same length at all points. Instead of plotting radial and circumferential velocities directly against the radius, the circumferential velocities are first converted into the corresponding angular velocities. Thus, if V a is the circumferential velocity of the generating point at a, the figure V a/length C a is plotted, and not V a itself. The ratio of areas corresponding to any point A is thus the ratio of an angle in radians to a radius increment in inches. If the ratio is, say, 0·1, or one-tenth, and point A corresponds to a radius increment of 1in., the relationship between the first point on the profile and the point corresponding to A will be the relationship between the extreme points of radius vectors originating from C, differing in length by 1 and spaced one-tenth of a radian apart. Starting with the vector which passes through the lowest point in the profile, every point

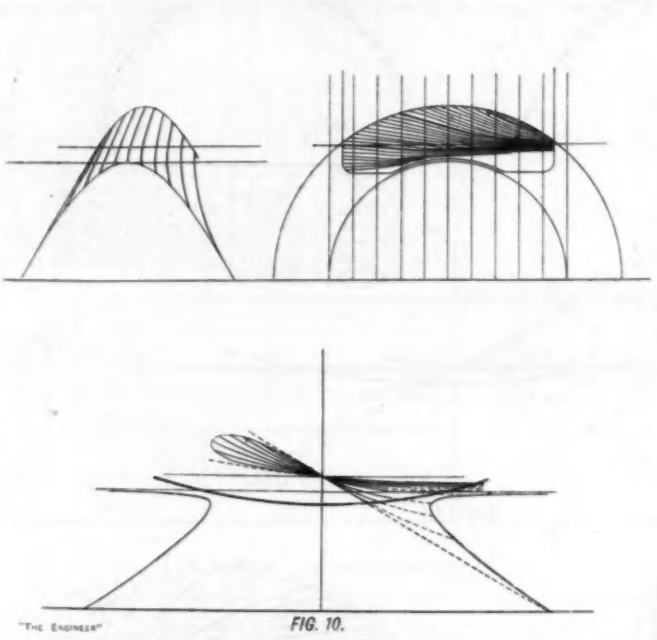


FIG. 10.

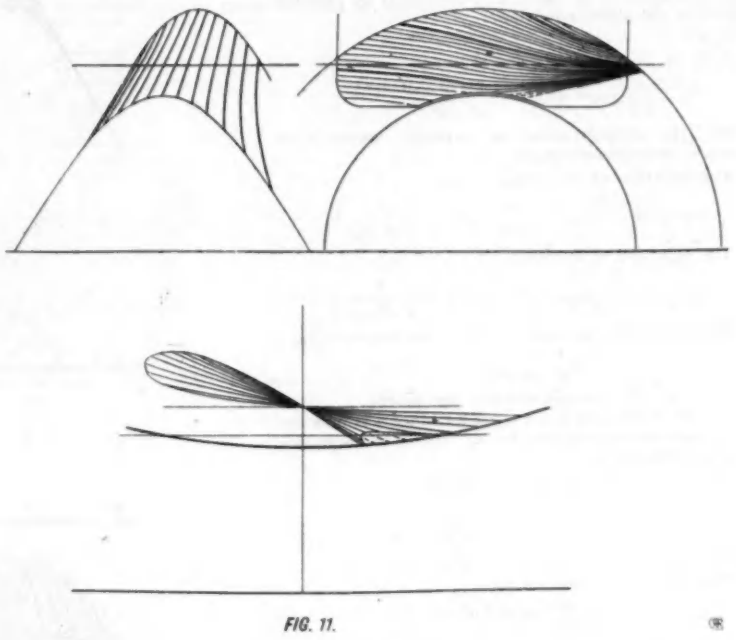


FIG. 11.

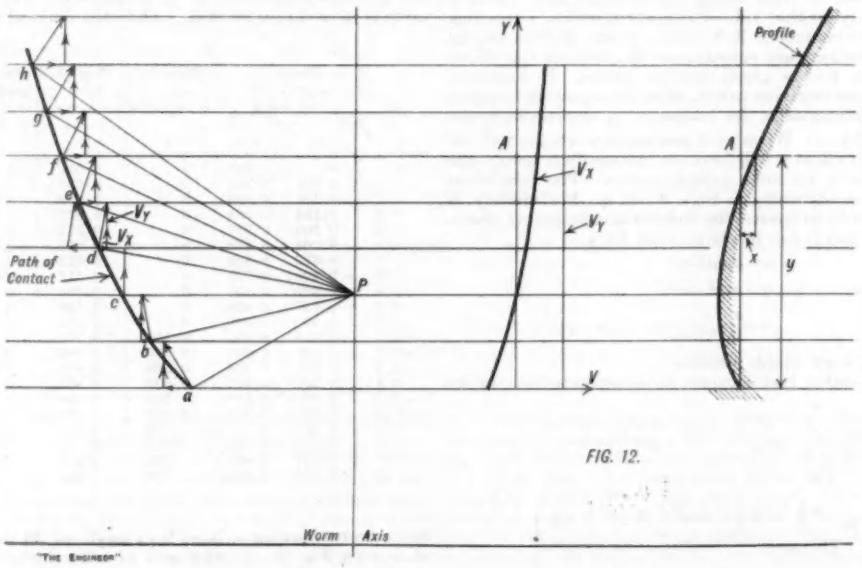


FIG. 12.

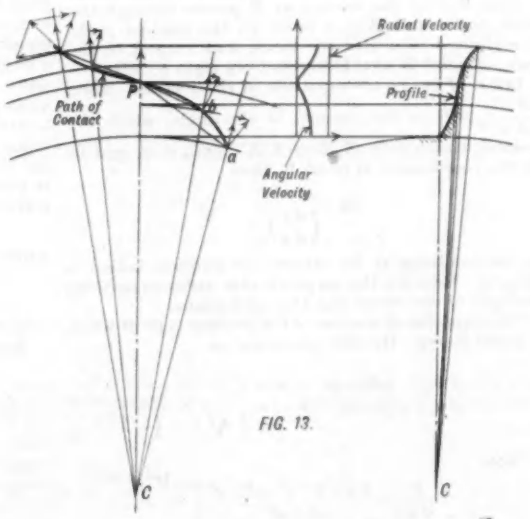


FIG. 13.

in the profile is located by a radius displacement and a radius increment.

On account of their low values, the radian measures obtained for the ratio circumferential velocity/radius may be multiplied by 100 or any other convenient factor before plotting the angular velocity curve. This will facilitate the measurement of the area ratios, though, of course, such ratios will need to be divided by the same factor before they are used to plot the profile.

The Iron and Steel Institute.

No. II. (*conclusion*).*

WHEN the meeting was resumed on Friday morning, May 6th, the awards of the Andrew Carnegie Research Scholarships for 1932–33 were announced as follows: Joseph William Cuthbertson, Roland Mitsche, Maurice Riddihough, Alan Scott, Cecil Rowley, Brynmor Jones, Wilhelm Kleinefenn, and Nicholas M. H. Lightfoot. The President then presented the Williams Prize to Mr. Arthur Robinson for the best and most informative paper offered during the past year, the subject being "The Melting Shop of the Appleby Iron Company, Ltd."

The remainder of the morning was largely occupied with the presentation and discussion of the Fourth Report on the Heterogeneity of Steel Ingots by the Joint Committee of the Iron and Steel Institute, and the National Federation of Iron and Steel Manufacturers to the Iron and Steel Industrial Research Council. The Report is a fairly stout volume, and we can do no more than extract portions from it which describe its contents.

THE HETEROGENEITY OF STEEL INGOTS.

The work of the Committee on the Heterogeneity of Steel Ingots has continued without intermission since 1924.

The First and Second Reports presented by the Committee in 1926 and 1928 were exploratory in character, and contained a detailed study of some thirty-two ingots, chosen as representative of normal practice. These included sixteen carbon-steel ingots, seven of alloy steel, and nine ingots representing the great tonnage of ingots cast from steel other than "killed." Their sizes ranged from less than 1 ton to more than 170 tons, and they made possible a general survey of the extent and manner of heterogeneity met with in everyday practice.

In addition, the Second Report contained a discussion on the influence of the mould upon segregation, and an indication of the influence of certain metallurgical characteristics of the steel upon its heterogeneity.

The Third Report, issued a year later, was somewhat different in character, and consisted of fundamental researches into several matters having a controlling influence upon the practical problems of the investigation.

In this, the Fourth Report, these two aspects of the work are linked together, but the Committee feels that the time has not yet come when an exhaustive analysis of the experimental results of the investigation, in the light of theoretical researches, can be achieved.

A precise study has been made of a further twenty-seven ingots, the experimental programme being designed to elucidate certain aspects of heterogeneity revealed by the preliminary work carried out during the first four years.

The subdivision of this Report is as follows:—

Section I.—A Further Study of Steel Ingots.
Section II.—Oxygen and Silicates in Steel.
Section III.—The Distribution of Silicates.
Section IV.—Principles involved in the Making of Rimming Steel.
Section V.—Pyrometry as applied to Liquid Steel.
Section VI.—Ingot Mould and Materials.
Part I.—Thermal Properties of Ingot Mould Irons.
Part II.—The Thermal Conductivities of Ingot Mould Irons.
Section VII.—Some further Mathematical Considerations concerning the Cooling and Freezing of Steel Ingots.
Section VIII.—Bibliography.

Part I. of Section I. is devoted solely to records of the conditions of manufacture of the ingots and their subsequent examination, whilst Part II. contains a discussion of the results of the investigation.

Section II. contains a brief account of the hydrogen reduction method for the determination of oxygen in steel and a discussion of the oxygen in the oxygen-bearing silicate inclusions disseminated throughout the ingot; whilst Section III., opening up a new feature of the investigation, deals in greater detail with the non-metallic silicate particles, their distribution and their composition.

Section IV. is devoted to a further and more detailed study of the principles underlying the manufacture of rimming steel.

Section V. is the report of the Sub-committee appointed to study the accuracy of pyrometric measurements at steel-making temperatures. This report deals in some detail with the calibration of the instruments, and full details of much experimental work give a clear indication of the accuracy with which temperature measurements on molten steel may be made, and the precautions which must be taken to ensure this accuracy. In addition, the thermal history of several ingots during the period immediately following casting is recorded, and throws considerable light on the separation of the ingot from the mould, and the discontinuity in the transference of heat across the ingot-mould boundary.

In Section VI. the study of ingot moulds is further elaborated from the standpoint of the physical characteristics of the mould material.

In Section VII. is a development of the interesting mathematical treatment of the problem of the distribution of temperature in the cooling ingot. This subject was introduced in the Third Report when three hypothetical cases were considered. In this section the case of a semi-infinite mass of steel bounded by a mould of finite thickness is developed to take into account the effect of preheating the mould, and the modifications introduced by a layer of scale on the interface between ingot and mould, and the formation of an air gap. Although the approximations necessarily involved make it impossible to calculate with accuracy the conditions in the centre of the ingot, a careful study of this contribution enables one to visualise very clearly the progress of freezing within 20 cm. of the ingot boundary, as well as the temperature gradients set up in the mould itself.

The early work of the first few years proved beyond doubt that the formation of ghosts and segregated areas in steel was but the inevitable consequence of the operation of physico-chemical laws, and that the manner and extent of such heterogeneity depended largely upon the mass of the ingot and the condition of chilling.

The later work presented in this Report further shows that the presence of non-metallic particles and ghosts in the ingot is largely governed by not only the process of manufacture but also the conditions of melting and refining in the furnace, and, in particular, the condition of the finishing slag at the moment of tapping, and the manner of addition of the deoxidants.

The experimental programme carried out during the past two years illustrates, in addition, the effect of the temperature of the metal, the size of nozzle, the rate of teeming, and the choice of deoxidants upon the heterogeneity of the ingot, and the position is now reached at which it is possible to predict and control with a certain degree of precision the segregation inevitably associated with even the best ingots produced by modern works.

Dr. W. H. Hatfield, the Chairman of the Committee, in presenting the report, emphasised the point that the Committee has now assumed a position of such importance that practically the whole of the resources of the country as regards steel production are behind it. When the Committee desired to examine any type of ingot every English steel company—and, indeed, companies abroad—gladly came forward and placed ingots at its disposal. The result was that this report gave the results of a careful study of some twenty-seven ingots under various conditions. In particular, he expressed the hope that the section on rimming steel would receive special attention in the discussion. It had sometimes been stated that certain types of steel could not be made in this country, but it was fair to say that there was no type of steel which could not be produced here. There was no difficulty on the part of our technologists in the various steel works in producing anything required once there was a technical understanding of the requirements. For instance, in the case of the rimming steel ingot dealt with in the report, it was quite clear that sheets rolled from that material had characteristics which from some points of view were dissimilar from those of sheets rolled from other types of ingot. Therefore, the Committee hoped that one of the results of the report would be to bring home the fact that if there was a complete knowledgeable understanding between the consumer and the steel producer as to exactly the type of material required, there would be no difficulty in producing it. As to Section III., on the distribution of silicates, it was felt that that was a matter for further investigation, and the members of the Committee were engaged in pursuing it further.

In the case of rimming steel, dealt with in Section IV., everything turned on the gaseous content of the steel and the Committee held the view that the evidence seemed to show that the purity of the rim was due to the scouring action of the gases evolved during freezing. There was, however, a paucity of real scientific knowledge on the gaseous content of steel, and that prevented the statement of underlying principles.

Dealing with Section V., pyrometry, it was pointed out that it became more apparent as the work proceeded that the quantitative control of casting temperatures was essentially a preliminary problem to be solved because experience threw doubt upon the means of determining quantitatively the temperatures of liquid steel. Therefore a special Committee was appointed consisting of half a dozen young and enthusiastic technologists engaged with pyrometry in their daily work to deal with this aspect, but in spite of the great advance that had taken place in pyrometry, the further advance that was necessary in the future could only be made with the whole-hearted co-operation and assistance of the physicists engaged in the works of the pyrometer manufacturers. The steel makers would like the pyrometer manufacturers in this country and throughout the world to rise to the occasion, and provide a more adequate means of scientifically controlling their processes.

Thanks were expressed to the British Cast Iron Research Association and Dr. Pearce for the assistance given in connection with Section VI. of the report, relating to the Thermal Properties of Ingot Mould Irons, the result of which was that substantially more was now known on that subject. That part of the report, however, could only be looked upon as interim, because the physical data required for a complete theoretical understanding of the problem must relate to much higher temperatures than had yet been explored.

Finally, in connection with Section VII., which dealt with Mathematical Considerations Concerning the Cooling and Freezing of Steel Ingots, Dr. Hatfield said that whilst it might be wondered why it was necessary to embark upon the mathematical field in that way, it had clearly been established that a great deal more information was required concerning time and temperature effects, &c., within the heavy cooling mass of an ingot, which could not be obtained by direct experimental observation. The work of Mr. Lightfoot had contributed in a marked degree to that part of the subject. Indeed, it was work which was receiving very earnest consideration not only in this country, but in Germany, Japan, and other countries abroad.

Mr. H. M. Duncan discussed in a critical and detailed manner various parts of the report, remarking at the same time that he regarded the Committee as being now the most authoritative body on the subject in the world. He suggested that the conclusions on page 4 of the report should be considerably modified in regard to examples 36 and 37 and 49 and 50, the details relating to which did not bear out the view that the presence of non-metallic particles and ghosts in the ingot was largely governed not only by the process of manufacture, but also by the conditions of melting and refining in the furnace, and, in particular, by the condition of the finishing slag at the moment of tapping and the manner of addition of the deoxidants. The statement of the Committee later in the report that the final character of an ingot was controlled largely by the slag-metal equilibria in the furnace itself, almost independently of the process by which the steel was manufactured, was not borne out by an examination of examples 49 and 50, when compared with examples 36 and 37. Dealing with other details of the report, Mr. Duncan suggested that it was necessary to read the results very carefully before any definite conclusions could be come to, otherwise they might be misleading. For instance, it was possible at first sight to assume that the lower the phosphorous the greater the heterogeneity, but there were cases in the report in which the phosphorous was high and the heterogeneity was low. As a turbine builder, continued Mr. Duncan, he was extremely anxious to obtain large charges as free as possible from segregates of silicates, but reading through the report he was almost forced to think that there were only three alternatives—first, that steel could be made in "any jolly old way," provided there were no blow-holes; secondly, that the heterogeneity disclosed represented the blanks of the experiments, *i.e.*, that if holes were drilled at some other point in the same ingot, and an analysis made, there would be a considerable difference; and, thirdly, the ingot examples were too small for heterogeneity to play any part. The results might have been totally different had the ingots been larger, and therefore it was essential to exercise care in drawing conclusions from results obtained with small ingots. It would also be an advantage if in future, test pieces were prepared so that a record could be obtained of the mechanical properties of the steel. If that had been done in the present case it would have been found that where heterogeneity was not disclosed between an oxidised steel and one made normally, there would still be a very great difference in the mechanical properties, thus confirming the view that for the highest class of work the steel must be dead melted, and very carefully controlled during its manufacture.

Mr. E. H. Saniter said that as to the ingots being too small, as suggested by Mr. Duncan, there were other types of segregation encountered with large ingots which were not encountered to the same extent in small ones. A great deal of work had been done in America, not only on silicate inclusions, but on all inclusions, and although some progress had been made it could not be said that the work had been very successful. Although the report contained a mass of information on rimming steel, there were still some weak points to be investigated. The information on ingot moulds would not help him to make a better ingot mould, but he was not at all sure that that was the intention of the Committee. It was rather to see the effect of the ingot mould on heterogeneity. There was the point, however, which did not strictly belong to this Committee's work, viz., the desirability of making an ingot mould which would give 200 casts, as was the case on the Continent. British moulds were improving in some cases, but it was not possible to get such a life out of them. That was not altogether due to the ingot mould makers, but very often to the way in which the moulds were arranged in the melting shop.

Mr. T. P. Colclough said the Committee would be gratified to hear that its reports were anxiously awaited on the Continent and America, where they were regarded as the standard work by the steel metallurgists of the world. The work being done was so important that he felt that the Committee should issue more frequent reports of a sectionalised nature. The two sections which interested him most in the present report were those on rimming steel and silicates and oxides. As regarded the former, a good deal of the argument was based on the oxide content of the steel and its relation to manganese, and use was made of certain research work by German metallurgists with regard to the balance of manganese and iron and their oxides in the reaction, and a value was given which he suggested the Committee might revise or look further into. He had found after examination of a good many heats in this country that, in basic practice, the constant given in the report did not represent the actual facts. The values suggested were not representative of British open-hearth practice as conducted in the basic furnace, the reason being that the data on which the conclusion was reached were obtained under special conditions, viz., with the use of a fairly high proportion of stahleisen, as was common on the Continent with a low phosphorous content of the metal and the slag, and as was also common in American open-hearth practice, with the result that the slags with which those heats were worked were not typical of our slags. The phosphorous content was extremely low, and the manganese content of the bath was relatively high, which gave an entirely different set of conditions from those obtaining here. In the British slags there was the possibility that the iron in the slag was not in the free state, yet that was postulated in the calculations in that part of the report. One aspect of the

* No. I. appeared May 13th.

Committee's work which was assuming even greater importance than the distribution of the elements was the distribution of the oxygen, and it was unfortunate that the Committee had not made a fuller use of the wonderful opportunity it had in that direction in the course of its investigation. He also felt that in regard to silicate oxides the Committee had examined only residues and not the inclusions which were present in the steel and which were causing the trouble. The total inclusions in the steel must be a function of the oxygen content, but the silicates as measured by the Committee could only be a function of the amount of silicon, manganese, and aluminium used to kill the steel, together with the original amount of oxygen present.

Dr. A. McCance said the Committee had collected such an enormous amount of data that it was difficult to get a clear picture of what exactly were the causes, but so far as he could see there was only one main cause that affected segregation, viz., the rate of cooling in the ingot. That seemed to be the only single factor that stood out clearly. Therefore, he suggested that the Committee should consider the question of devising some merit factor with regard to segregation so that one ingot could be compared with another more clearly and more simply than could be done by two or three pages of figures. He suggested an axial segregation figure of merit which might be obtained by subtracting the analysis in the H position from the analysis in the B position, and dividing that by the average: $\frac{H-B}{\text{average}}$, H being the position immediately under the head in the body of the ingot, and B the position nearer to the bottom of the ingot. The difference between those two, divided by the average, might give a clearer picture as to the amount of segregation that was taking place in either any particular shape of ingot or in any particular conditions. As to silicate determination, a great deal of work had been done in America in which it had clearly been shown that the amount of residue depends on the composition of the ingot, *i.e.*, that inclusions containing a high content of FeO were more soluble and did not remove so much residue as those containing a high silica content. The conclusions in Section IV. should be carefully revised, because they could only be accepted with some little reservation.

Mr. A. Robinson said it would save considerable confusion if the Committee would definitely decide to use the term "rimming" for steel which rimmed on setting in the mould. In the report the term was used sometimes to denote steel that rimmed on setting, and other times to cover all kinds of unkilled steels. Real rimming steel had its own definite good properties and uses for which rising and balanced steel were quite unsuitable, and the opposite also applied. It was quite impossible and undesirable to obtain true rimming steel containing 0·25 per cent. carbon and 0·65 per cent. manganese. The Committee had collected much information on the influences at work in the making of rimming steel, but a very great deal more was necessary before sufficient knowledge would be available. It was quite certain that in the manufacture of either type of steel the cast which had boiled well gave considerably less trouble from blow-holes and subsequent skin defects in the finished steel than the cast which had been stewed, and the hydrogen theory might explain some cases in which the effects of deoxidants did not come up to expectation.

Professor C. A. Edwards said that, in view of the possibility of misunderstanding in South Wales, it must not be assumed that the only possible way of producing the excellent rimmed steel illustrated in the report was by the basic Bessemer process. The section of the report dealing with rimmed steel was nothing more than an attempt on the part of the Committee to give a general *résumé* of the position, and any attempt to draw definite conclusions had been avoided.

Mr. J. H. S. Dickenson said the amount of information so far published in this country with regard to silicates in steel was extremely small, and even the section of the report dealing with that matter was neither as complete nor as conclusive as could be wished. Such silicate particles as had been found in steel, however, were undoubtedly connected with the condition of the steel at the time of casting, and if some sound method for determining silicates could be found it might prove to be quite a good way of checking the quality of steel, apart from the mere occurrence of the silicates themselves.

Dr. Hatfield, replying to the discussion, said the Committee was not likely to take exception to any of the criticisms that had been made. Mr. Duncan, of course, had his mind largely on turbine forgings, which involved larger masses than those dealt with in the report, but very large ingots had been dealt with in previous reports. Indeed, the Committee had dealt with ingots weighing up to 170 tons in weight, and there was a great deal of information in previous reports bearing on the points made by Mr. Duncan. The suggestion by Mr. Duncan that steel might be turned out "in any old way" was very far from representing the real state of things, because steel makers went to enormous trouble to produce the most satisfactorily refined steel. He hoped Mr. Duncan would withdraw that suggestion. Certain sections of the report were of fundamental importance. At one stage, two or three years ago, for instance, the Committee thought the obvious thing to do to further the inquiry was to make an ingot as dirty as possible, to pump as many inclusions of as large a size as possible into it, allow it to freeze, and then study the heterogeneity. Such an ingot was cast by the Bessemer process, over-oxidising, and the charge was blown for nearly a minute after it should have been, and there was a very rich oxide slag. Theoretically, the bath was charged with oxygen, the silicon and manganese were added, and casting took place as quickly as possible. In fact, there were all the conditions of a dirty ingot. The precaution was taken at the same time to cast an ingot in the ordinary way as a check, and it was found that the dirty ingot turned out, in fact, to be the cleaner of the two. That he regarded as true research, and really a very important contribution to the subject. It was really a question of the composition of the inclusions, and that experiment indicated that when there were rich oxides of iron present, a form of inclusion was obtained which readily separated from the steel.

With regard to basic Bessemer steel, he wished to make it perfectly clear that while the basic Bessemer process was the process largely used for the production of certain types of steel hitherto imported, it was the nature of the inside of the ingot which determined the application of the steel to a given operation, and the nature of the inside of the steel was entirely independent of the process. Further, the process used was determined by its cost under local conditions, and that could not be appreciated too much, because it was a fact of national importance. There was no reason whatever why a steel, such as was shown in Plate 39, which was a very good quality steel for certain purposes, should not be produced in any heavy steel works in this country, and, if so, that disposed once and for all of the suggestion that it was essential that we should be dependent upon the Continent for supplies of certain classes of steel. We were not. The remarks of Dr. McCance were very much appreciated, but he hoped it would be understood that the Committee was very careful not to state definite conclusions or even opinions where the points were doubtful. In all such cases it was said: "It has been suggested . . ." The suggestion by Dr. McCance as to devising a figure of merit with regard to segregation was a very good one, and an endeavour would be made to see if something on those lines could be done.

A paper by Dr. A. Kriz on "The Heterogeneity of a Sand-cast Steel Ingot" was then presented.

Dr. W. H. Hatfield recalled the delightful time the members of the Institute had had at the Skoda Works a year last September, and mentioned that the origin of that paper was the interest then shown in the magnificent piece of research done there by the author on that very large sand ingot. The Ingot Committee had published a report on a very small ingot, weighing 14 cwt., and another of 6 tons, but the sand ingot described in the paper weighed 26 tons, and therefore the contribution was a valuable complement to the work of the Ingot Committee. It was very generous of the Skoda Company to permit Dr. Kriz to give the information.

Mr. J. H. S. Dickenson said there were a number of very striking features about the ingot. For instance, the shape of the pipe was very interesting. One usually only found long parallel-sided pipes of that sort in ingots where marked secondary piping had taken place, and where there had been a certain amount of feeding from the hot top, resulting in freezing across the ingot a little below the hot top, giving a long vertical column of liquid steel cut off from the head. He wished the author had made some attempt to define the distribution of the non-metallic impurities in relation to all the other elements, but possibly it was not too late for that to be done.

It was intimated that the author would reply in writing.

This paper was followed by one on the "Behaviour of Manganese in the Acid Open-hearth Process," by E. Maurer and W. Bischof, which, in the absence of the authors, was taken as read. There was no discussion.

The meeting then adjourned until the afternoon.

When the meeting resumed on Friday afternoon, Mr. A. Hutchinson (Vice-president), took the chair. A paper entitled "The Action of Sea Water on Mild Steel," by Dr. G. D. Bengough and Dr. A. R. Lee, was read and discussed.

MILD STEEL IN SEA WATER.

Mild steel—see analysis below—in the form of horizontal discs, has been wholly immersed in sea water and a variety of salt solutions beneath atmospheres of air or oxygen for periods up to 150 days, and the following observations have been made:—

(1) A large proportion, often one-half, of the corrosion in sea water was found to be due to the evolution of hydrogen gas.

(2) In the absence of oxygen, no hydrogen evolution could be observed at the end of 110 days.

(3) With the rate of oxygen supply used in this research, the rate of corrosion in sea water beneath an air or oxygen atmosphere was usually found to be faster than that in $N/2$ NaCl solution. This was mainly due to the increased amount of hydrogen evolution.

(4) The rate of corrosion in sea water in the presence of oxygen was only about 20 per cent. faster than that in air; in $N/2$ NaCl the rate is increased by two and a-half times.

(5) Oxygen-absorption/time curves in sea water beneath an oxygen atmosphere were found to fluctuate about the mean position of the $N/2$ NaCl curve. These fluctuations were associated with the presence of magnesium and calcium salts.

(6) It has not yet been found possible to prepare a mixture of inorganic salts, with or without saponin, which would give the high rates of hydrogen evolution found with sea water. These high rates are probably associated with the presence of organic matter in solution.

(7) Partial removal of the organic material in sea water by means of animal charcoal or centrifuging had relatively little effect on the corrosive behaviour of the sea water, but treatment with boiling potassium permanganate caused its behaviour to approximate to that of a solution of mixed chlorides of sodium, magnesium and calcium similar in concentration to sea water.

It is suggested that the evolution of hydrogen gas may be an important factor in determining the adhesion of paints on steel immersed in sea water.

Analysis of Steel Used.

	Per cent.		Per cent.
Carbon	0·13	Nickel	0·20
Silicon	0·15	Chromium	0·04
Sulphur	0·034	Copper	0·05
Phosphorus ..	0·034	Oxygen	0·02
Manganese ..	0·46		

Professor T. Turner, opening the discussion, said the fact that hydrogen was evolved during the corrosion, as stated in the paper, was a new observation. In ordinary circumstances, the amount of hydrogen given off must be relatively small, and it must be given off slowly. He had never observed any evolution of hydrogen when the metal was immersed in sea water or in ordinary water in which rapid corrosion took place. The question of how hydrogen was formed was very interesting, and in that connection he recalled that a few years ago he had put a piece of bright iron into distilled water and boiled it, and then hermetically sealed it. In the course of time a very small quantity of white gelatinous material was formed loose and floating about, which, he presumed, was ferrous hydrate, resulting from the fact that the water was not absolutely free from air. The tube containing the specimen was kept for many years and, indeed, still existed, and the bright iron was perfectly clean. It was evident, therefore, that water alone would not liberate hydrogen or oxidise the iron, yet the water was decomposed. It could only be from the decomposition of the water that the hydrogen was evolved, and it would appear that the ferrous hydrate which was produced, in being oxidised, split up the water with the result that hydrogen was given off during the oxidation of the ferrous salt. If that was not the explanation he would like to know the authors' view of how the water was decomposed in that case. The fact was well known that synthetic sea water did not behave in the same way as natural sea water, because in natural sea water there were small traces of bromide, iodide and other salts which were not introduced into synthetic mixtures.

Dr. J. C. Hudson, summarising the work of the authors, said they had always held it to be a matter of fundamental importance to determine the corrosion time curves, *i.e.*, it did not suffice to measure the corrosion after one or two isolated periods, and the authors' apparatus lent itself admirably to the determination of the variation of corrosion with time. In the second place, the authors had emphasised that there was a fundamental difference between sea water and synthetic salt solutions, which was important in view of the tendency to use salt sprays for synthetic corrosion tests. Thirdly, the authors had rightly emphasised the importance of using material of known origin. Finally, they had brought out in an unmistakeable manner the fact that when iron and steel corroded in the presence of a liquid and oxygen, the action did not consist only in the absorption of oxygen, but also in the evolution of hydrogen. That may have been dimly recognised before, but there were still workers carrying on corrosion tests under conditions of complete immersion who only took into consideration the oxygen absorption and, therefore, their results were entirely misleading. The extension of that work to other samples of iron and steel, particularly ordinary steel and copper-steel, would be welcomed, because for a long time there had been controversy as to whether the addition of copper to steel was of any definite value in the case of marine corrosion. It seemed that the authors' apparatus would enable that point to be settled.

Mr. U. R. Evans said the authors had done good service in discovering conditions under which sea water was definitely more corrosive than sodium chloride. The marked elimination of hydrogen from sea water by immersed iron was previously suspected, and it clearly was a matter of importance. Nevertheless, one must not lose sight of the fact that there were circumstances in which sea water, owing to its magnesium salt content, might be less corrosive than pure sodium chloride solution of corresponding strength. Under the conditions observed by the authors, where sodium hydroxide and iron chloride would be formed very close together, it would be the iron and not the magnesium which would be precipitated and the failure to detect large amounts of magnesium compounds in the rust need excite no surprise. On the other hand, under boiler conditions magnesium salts were more destructive than the corresponding sodium salts, for in that case the corrosion was mainly of the hydrogen-evolution type, and the magnesium salts were more prone to hydrolysis, with consequent production of acid, than sodium salts. His collaborator, Mr. S. C. Britton, had compared the effect of subjecting steels and other materials to intermittent spraying with (1) sea water from Bognor, and (2) a 3·5 per cent. sodium chloride. On two varieties of scale-free iron and steel, the sea water was the less corrosive of

the two, whilst on other steels there was no very marked difference; whilst under some conditions sea water was more corrosive than sodium chloride solution, there were other conditions in which it was less corrosive, whilst there were still other conditions in which the two liquids corroded in a different manner. It was, therefore, necessary, as always, to use caution in applying the results of laboratory tests to a practical engineering problem. The fact that sea water evolved no hydrogen in the absence of oxygen rather suggested that there was not a simple displacement of hydrogen by iron, but that the hydrogen was formed from one of the corrosion products, as had been pointed out by a German investigator.

Dr. Lee, replying to the discussion, said that hydrogen evolution might be a factor to be taken into account in connection with paints, because a slight corrosion starting up anywhere might produce hydrogen which would push the paint off. With regard to the observations on hydrogen, he presumed that the hydrogen must come from the water and that it was simply turned out of the water molecule by electrolytic reaction, the degree being determined by the nature of the solution.

The second paper dealt with on Friday afternoon was entitled "The Determination of the Porosity of Tin Coatings on Steel," and was by D. J. Macnaughton, S. G. Clarke, and J. C. Prytherch.

POROSITY OF TIN COATINGS.

It has been found by the authors that when tin-coated steel is kept for some time in hot water of high purity, spots of iron rust appear over its surface. These spots are sharply localised and strongly adherent. To secure the maximum number of spots, the following conditions are essential:—

(*a*) The water must be of high purity. Small additions of any one of a wide variety of salts inhibit the test. Water prepared by distillation and storage under conditions free from contamination is satisfactory.

(*b*) The hydrogen-ion concentration of the water should be within the approximate limits *p* H 4·5 to 7. Thus, the water may be neutral or very slightly acid, but must not be alkaline. As a simple test, it has been found that the water is suitable if it gives a pink colour with methyl red indicator.

(*c*) The temperature of the water during the test should not be less than about 95 deg. Cent.

(*d*) The time of immersion of the specimen should be about 6 to 8 hours, or 3 hours if it subsequently remains immersed for an additional 18 hours in the water at room temperature.

Evidence indicates that the number of rust spots so obtained is a satisfactory index of the porosity of the coating.

Professor T. Turner said, in the discussion, that he had followed this work in connection with the Tin Research Sub-committee of the Non-ferrous Metals Research Association. The method described in the paper was quite new and simple, but required care in use.

Mr. H. Spence Thomas said the ferricyanide test had been discarded by the tin-plate industry for ten years. As a matter of fact, perforation of the tin-plate was practically unknown in the tin-plate industry and the canning industry in this country, although in the United States it was a common complaint. That freedom from perforation in this country, especially in Welsh tin-plate, was due to the fact that two separate pots containing different qualities of tin were used for treating the steel plate.

Mr. U. Williams asked if it was really porosity which the authors had observed. In passing through the palm oil and carrying with it a certain excess quantity of damp oil to the rollers, it was possible for small specks of iron-bearing material which existed in the atmosphere of a tin-plate works, to attach themselves to the material. These would react with the hot water and it would be interesting to know to what extent the authors were satisfied that they were, in fact, dealing with porosity and not with adherent particles.

Mr. Macnaughton, replying to the discussion, said the work described in the paper was the first step towards a reliable test for porosity. He did not think there was such a great difference between American plates and British plates as regards perforation as had been suggested. The chief objection to the hot water method was that it required six to eight hours to complete the test, and for that reason the authors had gone into the question of seeing if it was possible to standardise conditions for the paper test. Personally, he would always prefer the hot water test, but in order to obtain an approximation to works conditions a modified paper test should meet the requirements.

The final paper was one by Mr. G. Burns, on "The Properties of Some Silico-Manganese Steels."

ACCORDING to the annual report of the Gas-meter Testing Committee of the Justices, the testing of gas-meters in Birmingham in the year ended March last yielded a profit of £1178 3s. 4d., which went to the relief of the rates. The Committee states that the number of meters tested during the year amounted to 79,938, as against 82,272 last year. The general efficiency of the department continues, and the reasonable requirements of the manufacturers of meters and of the local authorities of the surrounding districts are being fully met. During the past year two additional outside authorities began to send their meters to Birmingham for testing. The income during the year amounted to £4887 5s., and there was again a substantial contribution to the rates of the city, which amounted to £1178 3s. 4d. The present staff consists of one inspector and twelve assistants, and the Committee feels that the satisfactory position of the department reflects great credit upon them, and especially upon Inspector Colburn.

Transient Voltage Stresses in Power Transformers.

By K. K. PALUEFF.

No. IV. (*conclusion*).*

NON-RESONATING TRANSFORMER.

IF an ordinary transformer could be made to distribute transient voltages uniformly along the winding, its ability to withstand these voltages would be most substantially increased, owing to the reduction of local abnormal stresses. Furthermore, once voltage distribution is made uniform for all shapes of incident waves, it would be possible to redistribute the same bulk of transformer insulation in the most rational manner. Thus, a further increase in strength could be affected by attaining a uniform factor of safety throughout the structure. It is obvious that such a factor of safety is the highest possible for a given amount of insulation.

The standard "induced voltage" test would subject all parts of such a transformer to stresses proportional to those encountered in service. As stated, a test at 3·46 times normal voltage causes stresses at the line end of the winding equivalent to the maximum transient stress allowed there by "standard" co-ordinated line insulation. It follows that in a transformer in which all parts are stressed uniformly, the customary induced voltage test would be a true measure of the ability of the transformer to withstand lightning and other transient voltages. Such a transformer has been developed. Since it cannot oscillate or resonate to any frequency, it has been named the non-resonating transformer.

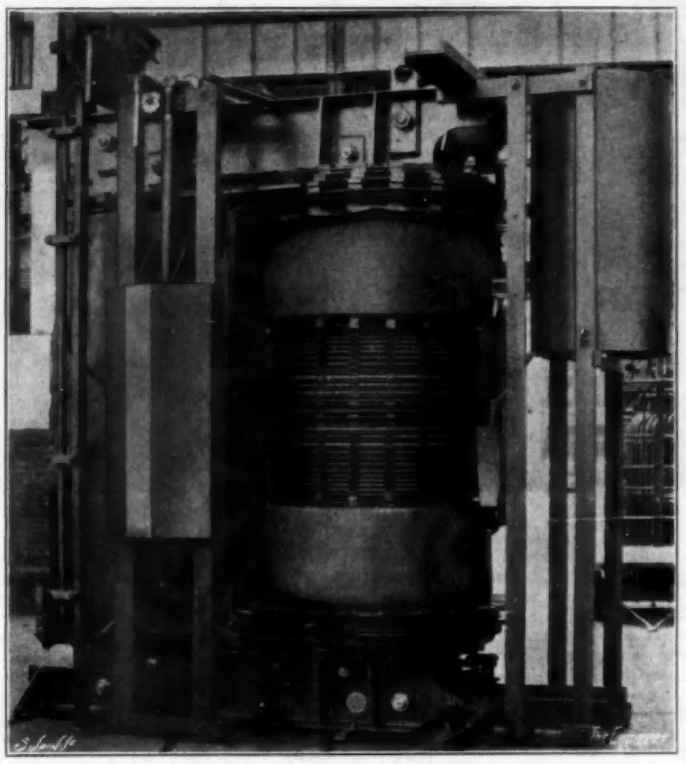


FIG. 24

13,000-kVA, 230,000-Volt Non-Resonating Transformer which was Subjected to Artificial Lightning Tests.

CONTROL OF VOLTAGE DISTRIBUTION.

(1) *Long Unidirectional Wave with Steep Front.*—As has been observed, the free oscillation in an ordinary transformer winding following the impact of a long wave with steep front was, in reality, a process of readjustment of voltage distribution from the initial to the final state. Such an oscillation, therefore, occurs only when the initial and final distributions are not the same. If these distributions are made to coincide this oscillation would be impossible. This is the basic principle underlying development of the non-resonating transformer.

Since it is desirable to have a transformer which is not only free of internal oscillations, but also distributes all voltages uniformly, it follows that the initial and final distributions should both coincide with curve 2 of Fig. 3 *ante*, and since the final distribution of an ordinary transformer is represented by this line, it is only necessary to modify the initial distribution to obtain the desired results. It should be recalled that the initial distribution is governed only by the electrostatic characteristics of the winding. For this reason, whatever means may be employed to modify the initial distribution, they must be directed toward changing the electrostatic field from that shown in Fig. 5 A and 5 B *ante* to one that is uniform from the line end to the earth end of the winding. This can be accomplished by properly proportioned metallic surfaces, or shields, placed near the windings. The resulting electrostatic field is shown in Fig. 5 C. The arrangement of shields and windings is shown in Fig. 24. The equivalent circuit of the non-resonating transformer is shown in Fig. 25. The formation of the electrostatic field in Fig. 5 C requires that the shield be so proportioned that the elementary capacitances C_{p1}, C_{p2}, &c., compensate for the effect of C_{s1}, C_{s2}, &c. As a result, the same current I_0 flows through all the C_w elements, and the voltage distribution along this path is uniform. A curve of initial distribution measured on a non-resonating transformer built for commercial use is shown in curve 6 of Fig. 26.

(2) *Finite Wave.*—If the voltage across the terminals of a non-resonating transformer should be abruptly reduced from $+e$ to zero after t microseconds, the potential of the entire winding would fall to zero simultaneously. This may be determined by the same method that was used above for an ordinary transformer. We again assume that at time t, $-e$ is abruptly applied without removing $+e$. This would produce the negative initial distribution shown by curve 3, Fig. 16 *ante*. When superimposed upon the final distribution immediately preceding t—curve 2, Fig. 17—this gives a resultant voltage of zero for the entire winding.

The general conclusion can be drawn that no matter how sudden the change of the terminal voltage of such a transformer may be, the internal voltage will rise and fall in synchronism with it, and its distribution throughout the winding will be uniform.

It is logical to conclude, and, in fact, it has been shown theoretically and experimentally, that if a travelling wave of sheer front and tail cannot produce internal oscillations, a wave with less abrupt changes of potential certainly will not produce them. Since the internal voltages are reduced to zero at the moment the terminal voltage falls to zero, it follows that no cumulative oscillations can be built up by a train of waves following each other at any intervals. Similarly, the application of an oscillatory wave cannot produce non-uniform distribution or abnormal voltages. Many tests have been made on various non-resonating transformers, using wave fronts shorter than a millionth of a second, as well as sustained and damped oscillatory waves covering a range of frequencies from some 2000 to 1,000,000 cycles per second. All of these tests substantiate the above simple theory. In contrast with an ordinary transformer, a non-resonating transformer can be compared to a perfectly rigid rod instead of an elastic ribbon. Such a rod cannot resonate to any applied frequency. Every point must rise and fall in synchronism with the "line" end, and with an amplitude proportional to the distance from the earthed end.

INVULNERABILITY OF NON-RESONATING TRANSFORMERS.

That the non-resonating transformer should, theoretically, be greatly superior to the ordinary transformer in regard to its ability to withstand transient voltage stresses is obvious. The question arises, however, whether this theoretical superiority is materialised in practice. That the voltage stresses are very materially reduced in non-resonating transformers built for commercial use is substantiated by the comparison of experimental data obtained on ordinary and on non-resohating transformers, and is shown in Figs. 26 and 27.

The durability of non-resonating transformers built for service to withstand the maximum transient voltage that can possibly be applied to them under service conditions has been demonstrated by lightning tests on one of fourteen 13,000-kVA, 230,000-volt transformers built for the New England Power Company. These tests consisted of application of over 200 surges to the transformer. The length of the applied waves ranged from a few to over two hundred microseconds. Wave length is taken as the time required for the voltage to fall to half of its crest value. Several of these surges were sufficiently high to cause arc-over of the transformer bushing. Approximately forty were above 90 per cent. of this value, and more than a hundred were above 60 per cent. A

* No. III. appeared May 13th.

large portion of the forty surges were obtained by arcing over a string of fourteen standard disc insulators, 10in. diameter and 5¾in. spacing, which is standard co-ordinated insulation for 230,000-volt systems.

The tests were followed not only by the standard A.I.E.E. tests, but also by careful examination of the major insulation of the transformer, and, after complete disassembly by minute examination of the turn and coil insulation. No damage was found. As far as could be learned, no other transformer at that time had passed such a test and inspection successfully. It should be appreciated that stresses produced by such a test are several times greater than those produced by the so-called "surge test," specified as a part of an acceptance test in some European countries.

The question may be asked whether the addition of shields, which are rather large surfaces maintained at line potential, may complicate the construction to a degree that would nullify the advantages gained by making the voltage distribution uniform. Fortunately, the problem of design and manufacture of shields is one of the simplest that confronts the transformer designer. It is simple because the effects of heating, short circuit forces, losses, &c., which are present in the rest of the transformer structure are absent here. Furthermore, the location of the shields on the outside of the winding gives the designer a freedom of

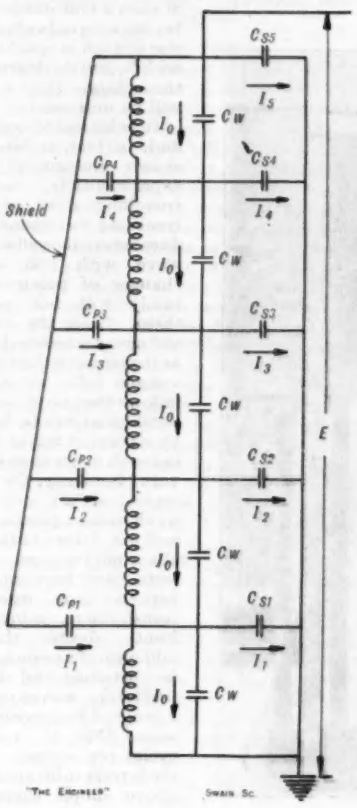


FIG. 25

Approximate Equivalent Circuit of High Voltage Winding of Non-Resonating Transformer.

choice for the shape of the shields, and permits more liberal insulation allowances than in any other part of the transformer, since increased distances from the winding to the shield do not conflict with other design requirements. For these reasons the effect of this extra factor of safety in shield insulation on the cost and overall dimensions of a transformer is negligible.

The shields consist of smooth conducting surfaces covered with a thick layer of solid insulation impregnated with a special compound. Wherever the voltage stresses justify it, the insulation between shields and winding is reinforced by a suitable number of pressboard or "Herkolite" barriers. The shields are spaced from the windings so as to allow free circulation of oil around both shields and windings. They are subjected to mechanical stresses only during shipment of the transformers. Particular care is taken to ensure ample strength in bracing and supporting structures, as well as in the shields themselves, so that no damage will result from any rough handling the transformers may receive during shipment. Since reliability has become the principal requirement of the electrical industry, the insulation between turns and coils that has been found practicable for ordinary transformers has been retained in non-resonating transformers, with a slight modification dictated by design considerations to give the best voltage distribution and highest overall factor of safety.

The insulation of non-resonating transformers is so proportioned that in case a voltage in excess of the safe value is applied, failure will not occur between the winding and shield. Therefore, to obtain a correct idea of the relative strengths of ordinary and non-resonating transformers, one must compare a given tranformers under two conditions of voltage distribution: first, the non-uniform distribution of the ordinary transformer, with high stresses to earth and between adjacent parts of the winding. Secondly, the uniform distribution of the non-resonating transformer, with uniform stresses throughout. Since the stresses are uniform throughout the winding in a non-resonating transformer, the breakdown strength can be specified in terms of the insulation strength from the line end of the high-voltage winding to earth. As previously shown, this cannot be done in the case of an ordinary transformer.

If the transmission line insulation adjacent to a non-resonating transformer is properly co-ordinated with the transformer insulation, as shown in Table II.,

TABLE II.

Rated circuit voltage.	Transformer 60-cycle test voltage.	Insulator 60-cycle dry flashover voltage.	Corresponding* No. of insulator discs spaced 5¾in. apart.
kV.	kV, R.M.S.	kV, R.M.S.	
69	139	250	4
92	185	350	6
115	231	400	7
138	277	450	8
161	323	550	10
196	393	640	12
230	461	725	14
—	510*	810*	16
—	570*	895*	18
—	625*	980*	20

* These do not appear in the rules as proposed, but are given here merely for reference purposes.

the transformer should be invulnerable to transient voltages. This is not necessarily true for ordinary transformers—see Fig. 19 *ante*—especially for those with graded insulation, as has been proven by service experience as well as by the theory discussed above. It has been suggested that, on account of shields, the total surface under voltage stress is materially

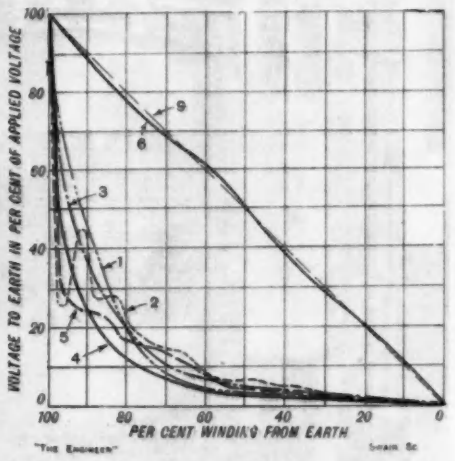


FIG. 26

Typical Voltage Distribution Curves Obtained by Test. 1.—Initial Distribution, 110,000 Volt, 6,667 kVA Core-Type (Palueff). 2.—Initial Distribution, 88,000 Volt, 5,000 kVA, Shell-Type (Palueff). 3.—Initial Distribution, 220,000 Volt, 25,000 kVA, Shell-Type (Vogel-Hodnette). 4.—Initial Distribution, 154,000 Volt, 22,900 kVA, Core-Type (Palueff). 5.—Initial Distribution, 140,000 Volt, 3,000 kVA, Shell-Type (Palueff). 6.—Initial Distribution and Maximum Voltage to Earth, 154,000 Volt, 22,000 kVA Non-Resonating (Palueff). 9.—Strength of Ideally-Graded Insulation.

increased, and therefore the chance of failure of a non-resonating transformer is proportionately greater than that of an ordinary transformer. While the fallacy of such a conclusion is obvious, it may be well, nevertheless, to emphasise the arguments against it.

Let a homogeneous sheet of insulation of uniform thickness be considered as an example. Let a small part of this sheet be subject to voltage stress. Since there is generally some variation in strength of different parts of the entire sheet, there are three ranges in voltage stress that should be considered. The lowest range starts at zero and ends at the value just below the voltage necessary to puncture the weakest spot of the sheet. The middle range starts at the stress necessary to puncture the weakest spot and ends at that which is necessary to puncture the strongest spot. The third range covers voltage above the strength of the strongest spot. It is obvious that only in cases where the applied voltage is within the middle range is the probability of failure proportional to the area and also depends on the voltage. For the other two ranges the result is a perfect certainty, and is independent of the area and voltage.

In any properly designed piece of apparatus the stresses are always kept well within the lower range. To accomplish this it is necessary to know the stress and the strength for every part of a structure. Since, in a non-resonating transformer the stresses are stabilised, and are distributed uniformly, their values are definitely known for any part of the winding. It is a simple matter, therefore, to distribute the insulation so that everywhere voltage stress per unit thickness of insulation is well within the lower range of stresses referred to above. It is far more difficult to attain the same degree of certainty in safety factor throughout a winding of an ordinary transformer, particularly because the local stresses there are from 2 to some 100 times those created in a non-resonating transformer, and their location shifts with change in character of the applied surge. It should be agreed that, if the stresses were allowed to reach the middle range, the probability of failure would increase with increased area of the insulated surface, and would cause the reliability of apparatus —whether transformers or generators, or any other apparatus—to fall with increase in their size.

It appears, therefore, that those who find the reliability of their transformers to fall with increase of the insulated surface are employing insulation at strength within the middle range.

Operation with Neutral Grounded Through Impedance.

All of the preceding discussion has dealt with transformers having neutrals directly earthed. When the neutrals are earthed through a reactance or resistance, or are isolated, the stresses in an ordinary transformer are generally higher than is outlined above. All of the desirable characteristics of non-resonating transformers are retained when transformers are earthed through properly designed neutral impedances, so-called "impedors."[18] The normal operating frequency characteristics of the impedor may be anything that is desirable from the standpoint of short-circuit currents, system stability, &c. As a matter of fact, there is a bank of large 230 kV,

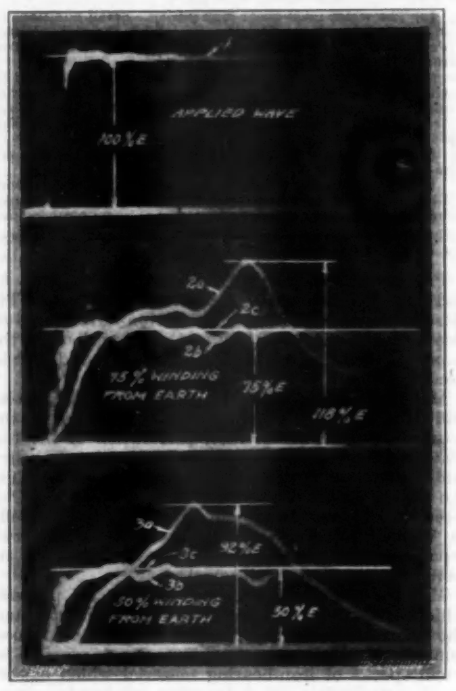


FIG. 27

Internal Voltages in Core-Type Transformer. 1.—Applied Wave. 2a.—75 per Cent. from Neutral, without Shields (Test). 2b.—75 per Cent. from Neutral, with Shields (Test). 2c.—75 per Cent. from Neutral, Ideal. 3a.—50 per Cent. from Neutral, without Shields (Test). 3b.—50 per Cent. from Neutral, with Shields (Test). 3c.—50 per Cent. from Neutral, Ideal.

non-resonating transformers which has been in operation for some time with an impedor so designed that at operating frequency the transformers perform as if their neutral were isolated from earth.

The conclusions to be drawn from these considerations are: (1) All transient voltages distribute themselves uniformly along the winding of a non-resonating transformer. (2) As a result of conclusion 1, there are no abnormally high voltage stresses from winding to earth, or between adjacent parts of the winding. (3) The uniform distribution of stresses makes a more rational distribution of insulation possible, giving the maximum obtainable overall factor of safety. (4) Oscillatory waves or trains of waves cannot produce cumulative oscillations in a non-resonating transformer. (5) Customary high potential and induced voltage tests are true measures of the ability of a non-resonating transformer to withstand transient voltages met in service; but this is not true for an ordinary transformer. (6) Since the electrostatic shields in a non-resonating transformer are located outside the high-voltage winding they do not interfere with the mechanical construction of the remainder of the transformer; all mechanical features and characteristics of commercial core-type transformers are retained in the non-resonating type. Ample insulation distance from shields to winding are used, since this does not conflict with other design requirements. (7) All the desirable characteristics of the non-resonating transformer are retained

[18] "Effects of Transient Voltages on Power Transformer Design," K. K. Palueff, A.I.E.E. Quarterly "Trans.," Vol. 49, July, 1930, page 1179.

THE PRETTYBOY DAM IN MARYLAND

when the neutral is earthed through a properly designed impedance. (8) If the transmission line insulation adjacent to a non-resonating transformer is properly co-ordinated with the transformer insulation, the transformer should be invulnerable to transient voltages.

The author gratefully acknowledges the assistance of his colleagues, particularly the helpful criticism of Messrs. D. M. Jones and J. S. Lennox, and the collaboration of Messrs. J. H. Hagenguth and W. A. McMorris in preparing the data.

Prettyboy Dam, Baltimore.

BALTIMORE, in Maryland, U.S.A., has now under construction on the Gunpowder River a second dam for the impounding of water for her people. This second dam is being erected with typically up-to-date facilities, and in one particular the work is being done in an exceptional way.

In 1881, when Baltimore first essayed to develop the watershed of the Gunpowder River, the city had a population of about 332,000. A dam was built on the river, and a connecting tunnel 7 miles long, which brought the water to a distributing point within the city limits, was constructed. Nineteen years later the population of Baltimore had increased to 509,000 souls, and the demands for water by the inhabitants and by industries had grown accordingly. However, the municipality was able to make the water resources suffice, even though there were times when a disquieting shortage was imminent. But action became imperative when the city expanded so as to embrace previously independent outlying communities, and the dam on the Gunpowder River at Loch Raven was raised 52ft. in order to increase the capacity of the impounding basin, and as a result the reservoir was made able to hold about 21 thousand million gallons. The watershed drawn upon has a drainage area of 306 square miles.

The watershed of the Gunpowder River is virtually Baltimore's main source for its water supply, and the basin formed by the heightening of the Loch Raven Dam has sufficed up to the present time, although restrictions in the use of water have been imposed several times in recent years during periods of drought. To-day, Baltimore has a population of more than 805,000 persons, and active steps were taken several years ago to prepare for the erection of a second dam on the Gunpowder River, some miles northward of the Loch Raven Dam. Actual work on the structure was started in November of 1930.

The site chosen for the new dam is approximately 25 miles north of the centre of population of Baltimore, where a valley of considerable depth forms the bed of the Gunpowder. It is officially known as the Prettyboy Dam site. The site is physically an admirable one, but some of the geological conditions necessitated the adoption of unusual precautions in the excavating of the cut-off below the level of the base of the impounding structure, which has called for the placing of about 190,000 cubic yards of concrete. The rock formation is composed in the main of mica schist with intrusions of limestone, gneiss, and quartz. Twice in past ages the formation was subjected to crustal movements, which caused faults, and where the rock has long been exposed it has undergone weathering to more or less pronounced depths. It was apparent to the engineers for the municipality that the utmost care would have to be exercised to guard against troublesome overbreak if blasting were employed in excavating. Indeed, there was a difference of opinion as to the general soundness of the rock and its capacity to support and to form suitable flanking anchorages for the dam.

As a preliminary, it was decided to drill several large and deep shafts, 36in. in diameter, which would permit consulting geologists, members of the staff of Johns Hopkins University, to be lowered into them so as to study the formation *in situ*. By adopting this procedure the geologists were able to make a concise drawing showing at different points the positions of all faults and large seams, as well as their drift and strike. This method of full-scale inspection of the rock also enabled the geologists to take truly representative samples wherever such were desired. The shafts sunk for this purpose were made with Calyx core drills equipped with cutting drums or bits, 36in. in diameter. But probably the most interesting use to which the Calyx drill was put was in connection with the excavating of the cut-off trench underlying the dam and extending up the slopes of the valley to provide keyways for anchoring the sides of the structure to the rocky walls of the valley or gorge. We shall quote the resident engineer for the city in describing this part of the operations.

According to the plans, the Prettyboy Dam was to have on the upstream side of the structure a cut-off trench, 6ft. wide and extending from 10ft. to 15ft. below the foundation level of the remainder of the dam. The specifications of the undertaking prescribed that this cut-off trench should be excavated with a channelling machine. No blasting was to be permitted on either of the sides of the trench, and only light blasting was authorised in getting out the rock between the contemplated flanking cuts. Theoretically this procedure seemed to be the correct one, but there were practical objections to its adoption.

It was apparent that a large number of horizontal steps would have to be excavated in both the foundation work generally and in the excavation of the cut-off trench, and these steps would have to be cut on both sides of the valley. The employment of a bulky and heavy channelling machine at any point would entail much difficult handling in shifting such a machine from position to position. The depth to which the trench would have to be cut at numerous places indicated the need of a succession of vertical risers on which to mount a channeller, and this, in turn, would require stepping in the sides of the various channelled cuts, in order to reach the ultimate depth called for on the plans. The alternative was to make the channelled slot a slanting one, so as to give sufficient width at the bottom to set up the track and to operate the machine in making each stepped cut below the topmost cut. In short, it was necessary, if practicable, to avoid excessive width of cut, so as to limit the amount of rock excavated. Furthermore, the end clearance required by a channelling machine at each vertical step would have prevented channelling being done for between 2ft. and 3ft. at these points.

The question was how to do the work without recourse to channelling or to the extensive employment of drilling and broaching. After due consideration, it was decided to utilise wire saws for the work. After some experimental tests, made at a slate quarry in Pennsylvania, but upon samples of the rock from the site of Prettyboy Dam, the Department of Public Works of Baltimore authorised the substitution of wire saws for channelling machines, provided, of course, that satisfactory results were obtained at the dam site. The contractor then bought four wire saws and a Calyx drill.

While the saws cut somewhat slowly through the mica schist at the dam site, and in a few places the rock encountered was so hard that line drilling and

broaching were resorted to, still they generally gave very satisfactory results. Owing to the lightness and flexibility of all parts of the saw rigs, the work proved less costly than would have been the case had channelling been employed. This conclusion is based upon previous experience with channelling operations under kindred conditions.

When the wire saws were used the procedure was as follows :—Holes 36in. in diameter were drilled with the Calyx drill to a depth of about 2ft. below the proposed bottom level of the cut-off trench, steel shot or "Calyxite" being used as the abrasive for the drill. Structural steel standards or tension posts—see Figs. 1 and 2—were set up in the Calyx drill holes at each end of the line of the cut. Each standard has a sheave which directs the cutting wire downward

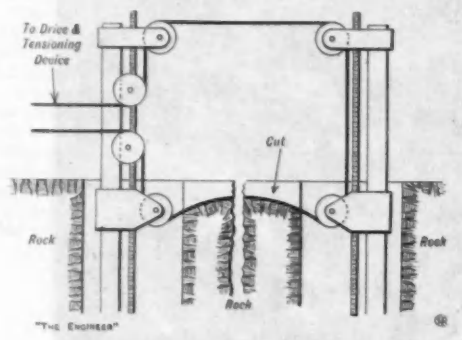


FIG. 1—ROCK CUTTING WITH WIRE ROPE

to a lower sheave, and the lower sheave is mounted in a cast iron frame that can be elevated or lowered by a screw shaft mounted parallel with the longitudinal axis of the standard. The cutting wire or saw was rove through the sheaves of the standards and carried from the standards, through conveniently placed sheaves, to a motor-driven, worm-geared driving jack, and thence to a weighted take-up device, set close to the jack at a suitable point. The ends of the wire were then spliced. Inasmuch as the sawing wire is made up of three special steel pre-bent strands, the pre-bending of those strands simplifies the operation of splicing because the ends of the strands do not have to be tucked. When the wire was rove and spliced the bottom sheave on each standard was screwed down, so as to bring the wire into contact with the top surface of the rock at a suitable pressure—see Fig. 1—and any underlying open spaces between the wire and the rock were filled with sand or loose earth, so as to prevent the loss of cutting sand and the swaying of the wire. Cuts were generally started with a wire ¼in. in diameter. When the foregoing preliminaries were completed the driving jack was started and quartz seashore sand was fed into the cut, where the wire entered, by means of a small jet of water. The wire moved continually in one direction, and carried the sand along with it, and the sand, acting as an abrasive, cut a slot the width of the wire. As the cut descended progressively, the lower sheave on each standard was screwed downward sufficiently to maintain a slight pressure on the rock.

Fig. 2, page 558, shows two sets of tension posts erected in two broken away Calyx drill holes. The upper pair is set for sawing away from the camera, whilst the lower pair will make two cuts towards it. Fig. 3 shows a section of the keyway for the eastern abutment of the dam. The saw cuts on the faces of the rock are plainly seen.

Cuts from 30ft. to 90ft. in length have been made with the wire saw, and the rate of cutting has ranged from 6in. to 20in. per 24-hour day, the depth depending, of course, upon the hardness of the rock penetrated. One saw wire, on a cut 30ft. in length, usually cut from 3ft. to 8ft. in depth before breaking, and the durability of the wire varied with the hardness of the rock. As soon as a wire wore down sufficiently to part a new and smaller wire replaced it, and the cut was then continued until the depth—varying from 6ft. to 8ft.—was such as to warrant the beginning of mucking operations. The trench was then mucked to the depth of the parallel saw cuts, and new saw cuts were begun with the largest size of saw wire.

Before the trenching is finished there will thus be removed approximately 3400 cubic yards of rock from the cut-off, and all but a small part of it will be sawed to the full depth on both sides of the trench. Again, by the time the work is done, the Calyx drill will have drilled fifty holes, varying in depth from 12ft. to 18ft., depending upon the depth of the cut-off trench at different positions. Of these holes, two have already been sunk for test purposes, and one of the two was carried to a depth of 57ft. Two other holes will be used for the setting up of saw standards and for the excavating of a vertical cut-off keyway in one of the vertical rock faces encountered in the dam excavation. These latter holes, when completed, will reach a maximum depth of 52ft. or more. Besides the deep holes mentioned, two test holes were drilled which are not associated with the cut-off trench, and they were carried to an approximate depth of 30ft.

The Prettyboy Dam—page 553—is a gravity poured concrete structure of the familiar ogee section. The spillway will be in the central part of the dam, with flanking non-overflow sections at the abutments. The dam is anchored to solid rock at all points. At its east end it is keyed into the rocky slope of the valley that rises considerably above its crest, but at its west end a short core wall ties it with the rock, which does not rise as high there as on the east side. This core wall is flanked by rolled earth embankments. The following general particulars will serve to give a comprehensive idea of the size of the dam and its outstanding features :—

Length along bridge	692½ft.
Extensions for water cut-offs into banks	162½ft.
Total overall length of concrete structure	855ft.
Spillway length four 68ft. 6in. clear arch spans	274ft.
Face-to-face abutments	344½ft.
Elevation of crest, mean sea level	520ft.
Crest above normal stream surface	133ft.
Foundation of dam below normal stream surface	20ft.
Bottom of cut-off wall below dam foundation	15ft.
Bridge side walks above crest	20½ft.
Total height of structure, exclusive of bridge balustrade and gatehouse	188½ft.
Maximum base width of highest part of dam	122ft.
Maximum length of apron	93ft.
Gatehouse projection upstream	29ft.
Maximum total upstream and downstream extent	244ft.
Bridge width : Roadway 20ft., two 5ft. 11in. sidewalks	31ft. 10in.
Total excavation, all classes	400,000 cubic yards
Rolled embankment	50,000 cubic yards
Total concrete, all classes	190,000 cubic yards
Outlet works : Two independent 54in. diameter cast iron pipe lines through gatehouse section, each line having twelve screens, four 3ft. by 5ft. rectangular sluice gates, one cone valve, and one 36in. diameter balanced free discharge needle valve	
Total estimated cost	2,150,000·00 dollars

The dam will serve as a viaduct connecting highways on both sides of the valley, and the programme contemplates completion of the structure by the end of October of the current year. Some of the features of the reservoir formed by the dam and the impounded area are as follows :—

Capacity	20,000,000,000 gals.
Area flooded	1500 acres
Water line length	46 miles
Reservoir length, along stream bed	7½ miles
Total land purchased, approximate	7300 acres
Total clearing	1650 acres
Total grubbing	20 acres
New bridges, overall length 412ft. and 585ft.	Two
Small bridges or large culverts	Five
Bridges abandoned : Main streams 9, minor streams 5	14
New concrete roads	5·15 miles
New macadam roads	4·8 miles
Time required to fill reservoir under normal rainfall and run-off conditions, with no draw-down and normal evaporation loss	One year

The estimated cost for the whole project, including the building of bridges, culverts, and connecting roads, the purchase of property, clearing of land, and allowances for some engineering contingencies, is put at 3,500,000 dollars, and the work should be finished by January of 1933.

The illustration—page 553—shows a finished section of the dam looking from west to east. The anchoring of the dam from foot to crest in the flanking hill will be noticed.

Outdoor Sub-station Lattice Steel Structures.

By A. M. SPRUCE, A.Am.I.E.E.

No. I.

GRAPHIC METHODS OF DETERMINING MEMBER FORCES AND CONSIDERATIONS AFFECTING THE DESIGN OF LATTICE STEEL STRUCTURES.

THE lay-out and electrical design of high voltage outdoor open-type sub-stations is the responsibility of the electrical manufacturer, but the steel work design and fabrication is usually, although not always, carried out by structural engineers specialising in this work. In cases where the steel work is sub-let in this manner, a proper design co-ordination should exist between the two manufacturers, in order that the resulting design may be economical, efficient, and comply with any electrical and structural specifications issued. To this end, therefore, it is desirable that each manufacturer should have a certain design knowledge of the other's work.

The electrical lay-out is the first essential, and often no structural design can be carried out until this has been decided. On the other hand, with certain types of switchgear, the supporting structure is automatically suggested and no difficulty occurs in obtaining a single-line lay-out. The choice for this supporting structure lies between two alternatives, viz., the standard single member construction, and the built-up compound lattice type. No actual line of demarcation exists to differentiate between the use of either type, but a decision may be made by consideration of the four following major points :—

(*a*) The type and amount of switchgear to be supported.
(*b*) System voltage.
(*c*) The ground space available.
(*d*) Strains imposed on the structure by incoming transmission lines.

In the single-member construction, standard rolled steel sections, either angle or I beams, are employed for the columns and girders. This type of supporting structure is used for many outdoor stations even up to 110 and 132 kV, but at these and higher voltages the switchgear phase centres become large, and necessitate depth being given to girders to retain the deflection within safe limits. A lattice compound structure, therefore, may be essential to protect against excessive girder deflection.

With a high type of station in which the structure itself also forms an anchorage for the transmission line conductors in place of a strain tower, the bending moments set up in the columns may be considerable, and with a single-member construction the sections necessary to withstand these moments would be large and heavy. In this case a modified structural design should be considered in order to economise in steel work weight, and this can usually be effected by employing lattice columns, with either parallel or tapered faces. The dimensions of the column base in lattice structures are, to a certain extent, a matter of choice, and the moment of inertia of the complete box section can be made any desirable quantity. Generally, these dimensions will depend upon the height of the column, the overhead pulls of either transmission line or bus-bars, and the clearances necessary for oil switch withdrawal. A point to bear in mind when fixing the column width, is the support given to them by any transverse or longitudinal cross girders.

The width of the cross girders in lattice structures is generally fixed by the width of the columns, but their depth can be regulated according to the span and dead load of the switchgear to be supported. In addition, the girders may be called upon to take horizontal strains due to supported electrical connections, and in all cases a wind load assumed acting normal to the side face.

Before any member stresses can be computed therefore, the magnitudes and position of all external forces must be known, and their effect on the resulting structural design employing various types of bracing is here considered.

Many forms of bracing are employed to take the shearing forces acting on a column or girder, and, depending upon whether these forces cause a compressive or tensile stress in the members, they are so designed as struts or ties respectively. The ideal design is that a structure should be a "perfect" frame, i.e., one without redundant members, but having just sufficient to keep it in equilibrium without straining the joints. In an "imperfect" frame its stability depends upon the rigidity of the joints, and further members are therefore necessary. It is usual in the stress solution of framed structures to neglect the rigidity of the joints, and assume them pin-connected or free to turn. Moreover, the external loads and forces, whether due to wind, bus-bar strained connections, or switchgear deadweights, are assumed to be acting at panel points or nodes. In sub-station design the point of application of these loads, excepting wind force, are fixed, and the bracing members should be so arranged that the resulting shear forces are transmitted direct to the booms. If, for some reason, any external load must be arranged between the panel points, local bending stresses will be set up in addition to the main bending moment, and with heavy loads this local bending moment is considerable, necessitating a heavy section.

The solution of framed structures in equilibrium is based on the principle that the vector sum of all the internal and external forces meeting at a point—concurrent forces—is zero ; or, the force polygon representing the member forces in magnitude and direction, closes, for otherwise the single force closing the polygon would represent the resultant of the vector sum of the separate forces. For example, in Fig. 1 the force of 2000 lb. acting at the top of the column and the two member forces meeting it are in equilibrium, and represented by the triangle 2–11–3 in the force polygon. Similarly, each joint is considered in rotation and its force polygon drawn, the complete diagram forming a single figure as shown. In drawing the force polygon a clockwise or anti-clockwise direction round the joint considered in the frame diagram must be chosen and adopted throughout. By this means the direction of the internal forces can be obtained, showing if the members act in compression or tension. For member designation in a frame diagram, Bows' notation is usually employed whereby a member is known by the space numbers on each side of it. Thus, in Fig. 1, the force of 2000 lb. is force 1–11, both in the frame and force diagrams. In all cases the loads shown are one-half the actual external loads, as one face only of the column or girder must be considered.

Columns.—The most simple system of column bracing is the single-lattice type, shown in Fig. 1, and is adopted both in sub-station and transmission tower design. Its use, however, is limited to narrow base columns and masts, for otherwise the unsupported length of the compression members becomes too great for the load, resulting in an uneconomical structure. The thick and thin lines in the frame diagram denote compression and tension respectively, with the arrow heads pointing towards the joint in the former members, and away from the joint in the latter. As seen in Fig. 1 the forces in the bracing members will be alternately tension and compression

commencing from the top, and a main compression leg on the right and tension on the left. An angle section would be used for all the compression members, and, where the pull of the bus-bars or other connections predominates over wind forces in an opposite direction, flat iron could be used for the tension members, but in practice the same angle section is retained for all bracings, resulting in a manufacture economy and a minimum number of different sections.

The angle θ or bracing inclination should as a rule not exceed 45 deg., and in many cases will not be as great as this. In both columns and girders the bracings are called upon to take the shear forces, and the main legs the bending moment due to external forces. As seen in Fig. 1, with a column subject only to a bus-bar pull at the top, the shearing force will be the same throughout its whole length and equal to 2000 lb., and the bracing forces represented to scale by any of the force lines 2–3, 3–4, 4–5, and 5–6, &c., which equal 2000/cos θ lb. A horizontal member is theoretically required at the ground level denoted by R–10 to take a shear force of 2000 lb., and if this member is not supplied the force is taken by the foundation itself. No forces exist in the bars 2–11 and 2–1, and, assuming that the base bar is supplied, the complete structure is a perfect frame, as shown by the following formula :—

$$\text{For a perfect frame } B = 2J - 3 \quad . \quad . \quad (1)$$

where B equals the number of bars in the structure and J equals the number of joints in the structure. In Fig. 1 the number of bars equals 17 and the frame has 10 joints. Substituting these values in equation (1), we have :—

$$17 = 2 \cdot 10 - 3 = 17.$$

The force in main leg 11–9 at the base of the column will be given by 11–9 in the force diagram, and the compressive ground reaction 11–R equals the vector sum of 11–9 and 10–9 and is shown dotted in the force diagram. If W lb. equals the weight of the column plus any supported girders or switchgear dead loads, then the total reaction 11–R equals force 11–R $+W/4$ lb., and the tensile reaction R–1 equals $10\text{–}1 - W/4$ lb. A maximum bending moment of 2000×24 lb.-ft. occurs at the ground level, which gradually diminishes as the height increases, becoming zero at the top.

It is usual with this type of bracing, and the majority of types mentioned later, to employ the same bolt or rivet for securing the ends of two bracings to the main column leg, assuming only one bolt is used. Every alternate bracing, therefore, will lie on the outside of the column and intermediate ones on the inside. By this means it is seen that the cost of fabrication is reduced, for only one rivet per brace end is used instead of two, as would be the case if all bracings were fixed to the outside or inside web of the main leg. Further, the rivet will be in double shear instead of single and the efficiency of the joint increased as the approximate centres of gravity of all the members meet at a point, a fact which reduces to a minimum the excentricity of loading.

With the column bracing as in Fig. 1, and subjected to a distributed wind load acting in the same direction as the main bus-bar strain, the force diagram will be modified as shown in Fig 2. Here both the main legs and bracing stresses are increased, due to the added wind pressure.

If Fig. 1 be further modified to include the vertical loads of supported overhead girders and switchgear, the resulting force, shear, and bending moment diagrams are as given in Fig. 3. In drawing the force diagram the external forces must be set down to scale in cyclic order, either in a clockwise or anti-clockwise direction considered round the frame diagram ; it should be noted that in all the multi-force diagrams given here the former direction has been adopted, *i.e.*, the forces set down in the order 1–2, 2–3, 3–4, to 15–16 in Fig. 3. With this condition of loading the maximum bracing force will exist in the lowest bracing member 13–14 and represented to scale by 13–14 in the force diagram. The shearing forces and bending moments will decrease as the height above ground increases as shown in the diagrams, the maximum bending moment being at the base of the column in member 16–13 and equal to

$$(2000 \times 24) + (400 \times 21) + (400 \times 15) + (400 \times 9),$$
$$\text{or } 66{,}000 \text{ lb.-ft.}$$

A modified system of bracing to that given in Fig. 1 is illustrated in Fig. 4, where a horizontal and diagonal bracing replace one diagonal member in the former figure. With a 2000 lb. force acting at the top in a direction from left to right the horizontal bracings will be in compression and the diagonal ones in tension, the main legs being stressed as previously. Although the total length of the complete bracing is greater than would be required for a single diagonal type, a saving is effected by reducing the duty imposed upon the struts. Comparing the force diagrams in Figs. 1 and 4, it is seen that, not only is the force in the compression members reduced to the actual shear force value, cos θ being equal to 1, but their unsupported length is also decreased to approximately the column width. Assuming the same column loadings, a more slender section may be chosen for this member, agreeing in all probability with the sections required for the ties, and resulting in only a slight increase in steel work weight. If, however, the external load is reversed, a complete reversal of all the forces in the bars will occur. The horizontal bracings will now be in tension, and the inclined bracings in compression requiring the same section as the compression members in Fig. 1. The steel work weight will consequently be increased, for here there are eight struts, but only four in Fig. 1 having the same length and cross-sectional dimensions. In short, with this type of column due consideration must be given to the bracing system depending upon the direction of the external forces.

One advantage of this construction employing horizontal bracings is, that at intervals in the column length of about 7ft. or 8ft. internal horizontal cross angles can be fixed. These take up any torsional forces occurring under load and during assembly tend to maintain a uniform parallel faced column free from twists, particularly in high rather than short columns.

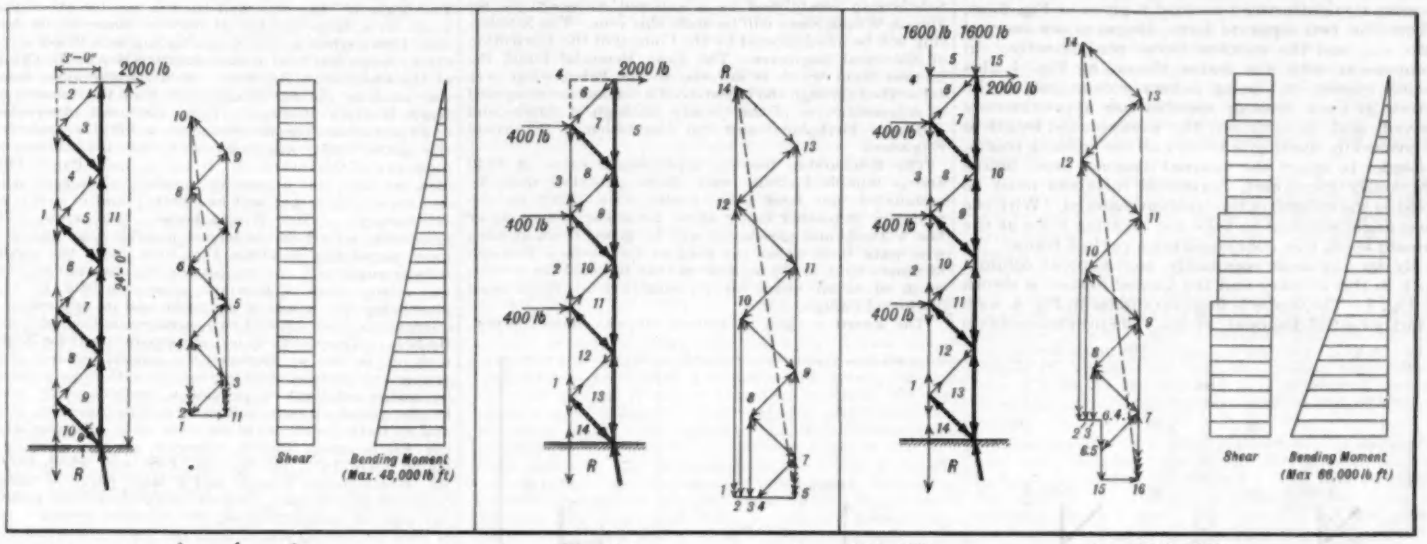

2000 lb
Shear
Bending Moment (Max. 48,000 lb ft)
SCALES- Frame 0 4 8 ft
Force 0 3200 6400 lb
Shear 0 3200 6400 lb
Bending Moment 0 40,000 80,000 lb ft
"THE ENGINEER"

FIG. 1 FIG. 2 FIG. 3

Applying the perfect frame test to this structure as given in equation (1), and assuming that the base bar denoted by 17–R is inserted, we have

$$31 = (2 \times 17) - 3 = 31,$$

showing this column also to be a perfect frame.

From the two previous types of column bracing a third is developed, consisting of a single-lattice bracing with horizontal bars fixed at all panel points, splitting up the main legs opposite the joints into two equal parts, as shown in Fig. 5. This splitting up in the case of the compression leg reduces its unsupported length, and means that the stress intensity with the same angle section can be increased, or, for the same force, a smaller angle adopted than in the frame given in Fig. 1. A consideration of the stress diagram will show that many of the space numbers fall on the same point, meaning that the bars denoted by these numbers are not stressed. These unstressed members are the horizontal bars, and their chief function therefore is to split up the compression leg.

A type used extensively for outdoor sub-stations is given in Fig. 6 (*a*), illustrating a double-lattice type composed of two single-lattice bracings superimposed on each other. Theoretically this forms a statically

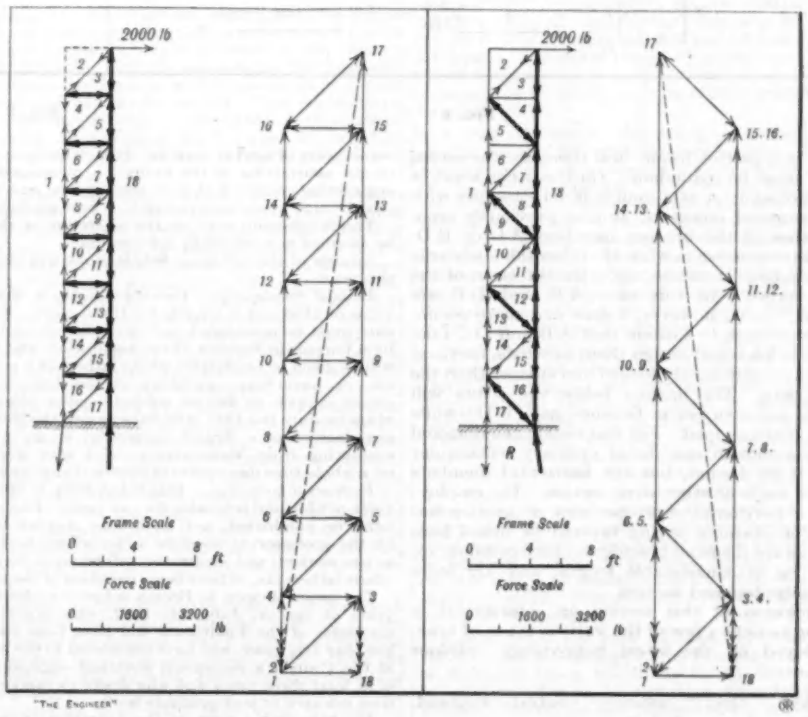


FIG. 4 FIG. 5

indeterminate structure, but can be solved fairly accurately by assuming that member 2–1 is omitted and that one half of the total load—in this case 1000 lb.—is applied at the top of each bracing system. Fig. 6 (*b*) gives the graphical solution for the separate bracing systems employing two force diagrams, the total force in any member being found by adding the common forces in the two diagrams. Thus, the force in frame member 24–27—Fig. 6 (*a*)—is given by the force 10–11 plus 9–11 from the stress diagrams in Fig. 6 (*b*), which to scale is 8000 lb. plus 7000 lb., or 15,000 lb. The bracing member forces, however, are given directly for either system and are not combined. A more straightforward method is given in Fig. 6 (*a*), where the two separate force diagrams are merged into one, and the member forces read directly. In comparison with the frame shown in Fig. 1 this double system of bracing is very economical, as the forces in each bracing member are approximately halved, and, in addition, the unsupported length is decreased by riveting or bolting all the crossing points. In order to insert the internal diagonal cross braces previously mentioned, horizontal members must be fixed to the column in the position required. With the base angle supplied to take the shearing force at the ground level, this column forms a perfect frame.

By far the most commonly used type of column, both in this country and the United States, is shown in Fig. 7. The frame is built up similar to Fig. 4, with a further set of diagonal braces. The previous column

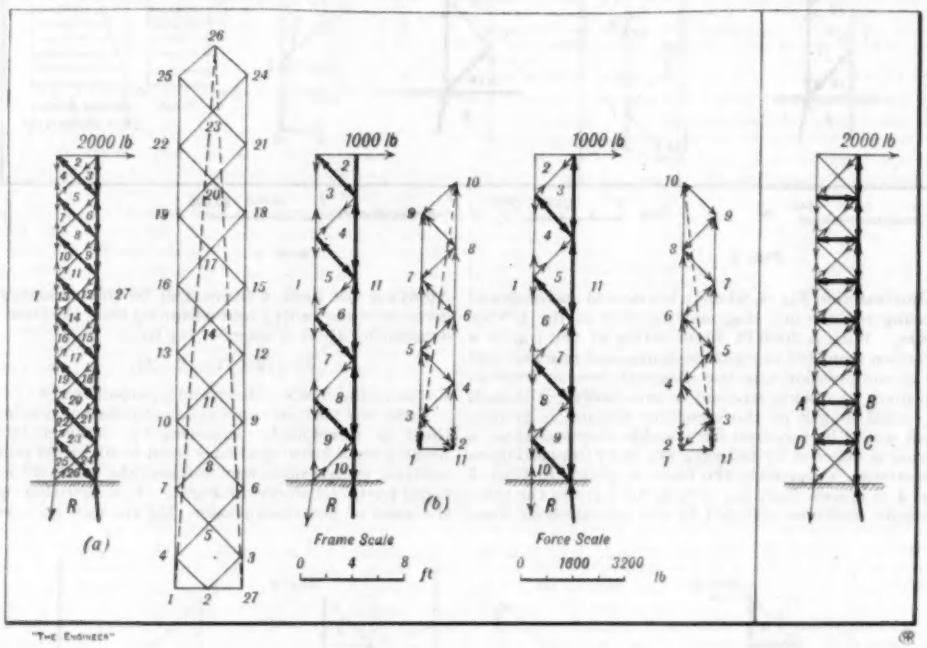


FIG. 6 FIG. 7

however, is a perfect frame, and therefore the added members must be redundant. On the other hand, it may be looked upon as a double-laced structure with added horizontal members, and, as previously seen, one or other of the bracing members A C or B D, Fig. 7, is in compression, while the other takes a tensile load, depending, of course, upon the direction of the external forces. In this case A B and D C are redundant. It is, however, better and more economical in steelwork to assume that A B and D C take compression loads and design them as struts, for these members are more lightly loaded and shorter than the diagonal bars. The bracing below the struts will then have one member in tension—say, B D—while the other takes no load. For this reason the diagonal lacing on a column may be of ordinary rectangular flat iron if so desired, but the horizontal members must be of angle or other strut section. The employment of a horizontal strut becomes of greater importance on stations having tapered or broad base columns, as the diagonal bracings on such columns are likely to be of considerable length, and are more economically designed as ties.

In conclusion of this section on columns, it is interesting to note a few of the various types of bracing employed on the latest high-voltage outdoor stations :—

132-kV "Grid" scheme, Central England, parallel face type to Fig. 6.

132-kV "Grid" scheme, South-East England, parallel face type to Fig. 6, with added horizontal internal bracings at intervals up the columns.

132-kV "Grid" scheme, Central Scotland, Greenock and Dalmarnock stations, parallel face type to Fig. 5.

220-kV system, Rhineland-Vorarlberg scheme, Germany, Brauweiler station, transformer bays parallel face type to Fig. 5.

220-kV system, Hydro-Electric Power Commission of Ontario, Leaside station, tapered tower type as Fig. 7, others to Fig. 1.

110-kV system, Shannon hydro-electric scheme, Dublin station, main corner columns tapered type to Fig. 1.

66-kV system, Shropshire, Worcestershire and Staffordshire Electric Power Company, Hester's Way, Cheltenham, switching station, transmission line supports special tapered type to Fig. 4.

(To be continued.)

Scholarships in Electrical Engineering.

Swan Memorial Scholarship.—The first award of the Scholarship established as a national memorial to Sir Joseph Wilson Swan will be made this year. The Scholarship will be administered by the Council of the Institution of Electrical Engineers. The Swan Memorial Fund, the interest from which is devoted to the Scholarship, was subscribed through the initiative of a Committee composed of representatives of the County Borough of Sunderland—Swan's birthplace—and the Institution of Electrical Engineers.

The Scholarship has an approximate value of £140 and is tenable for one year. Each candidate must be nominated, not later than August 15th, 1932, by the professor or teacher under whom he or she is working or has worked, and preference will be given to candidates who have been either (*a*) born in the County Borough of Sunderland, or (*b*) resident in that Borough for a minimum of seven years, or (*c*) educated at Sunderland Technical College.

The award is open to British subjects under twenty-seven years of age on July 1st, 1932, who have completed to the satisfaction of the Council a recognised electrical engineering course of at least three years, and who desire to carry out whole-time research or post-graduate work.

The Scholarship may, at the discretion of the Council, be awarded as a travelling Scholarship.

Awards of the following Scholarships will also be made this year :—

Duddell Scholarship.—This Scholarship is of the annual value of £150 and is tenable for three years. Each candidate must be nominated, not later than June 15th, 1932, by a Corporate Member of the Institution, and preference will be given to candidates whose fathers or a near relative are, or have been, members of the Institution. The award is open to British subjects under nineteen years of age on July 1st, 1932, who have passed the Matriculation examination of a British university, or an examination exempting from Matriculation, and who wish to take up a whole-time day course in electrical engineering.

Ferranti Scholarship.—This Scholarship is of the annual value of £250 and is tenable for two years. Each candidate must be nominated, not later than August 15th, 1932, by the professor or teachers under whom he is working, or has worked, and preference will be given to candidates whose fathers are, or have been, members of the Institution.

The award is open to British subjects under twenty-six years of age on July 1st, 1932, who are students or graduates of the Institution and have been such for not less than two years, and have completed to the satisfaction of the Council a recognised electrical engineering course of at least three years and who desire to carry out whole-time research or post-graduate work.

The Scholarship may, at the discretion of the Council, be awarded as a travelling Scholarship.

Silvanus Thompson Scholarship.—This Scholarship is for works' employees, and is of the value of £100 per annum and tuition fees, tenable for two years. Each candidate must be nominated, not later than June 15th, 1932, by a corporate member of the Institution and must be the son of parents of limited means.

The award is open to British subjects under twenty-two years of age on July 1st, 1932, who (*a*) have served a minimum apprenticeship, or its equivalent, of three years at an approved electrical engineering works, and (*b*) in addition to having taken full advantage of available opportunities for technical education, have acquired a marked degree of skill, and/or shown evidence of originality. The successful candidate will be required to take up a whole-time day course in electrical engineering at an approved university or technical college.

Applications, specifically mentioning the name of the Scholarship, for particulars of and nomination forms for any of the above Scholarships, should be addressed to the Secretary of the Institution, Savoy-place, London, W.C. 2.

SIXTY YEARS AGO.

OUR issue of May 24th, 1872, is of historic interest in that it contained the first mention to be made in our columns of the Westinghouse brake—"so called because the inventor is a Mr. Westinghouse, of Pittsburgh, U.S." The brake at that date had been in use for about three years on a large number of lines in America, no fewer than 1200 engines and 4000 cars having been fitted with it. Credit for its first trial in this country is due to Mr. Connor, of the Caledonian Railway. At a slightly later date it was tried on the St. Albans branch of the London and North-Western Railway. From our own observations of its performance on the second-named line, we were from the outset fully impressed with the importance and ingenuity of the invention. It was no mere Patent Office idea, we said, but a practical mechanical success, which had been fully tested and had been found in every way satisfactory. "Mr. Westinghouse," we wrote, "has practically solved on the largest possible scale one of the most perplexing problems that ever beset the modern railway engineer." Accompanying the issue named above was a large sheet of drawings, measuring 36in. by 27in., illustrating the details of the brake and its application to a locomotive, tender, and two carriages on the Caledonian Railway. There were two quite separate articles dealing with it. In one we discussed the general features of the system and contrasted its advantages with those possessed by earlier attempts to provide a continuous air brake. In the second we gave a detailed description of its parts, and set forth the results of the tests made on a train which left Bridge-street Station, Glasgow, on the morning of March 28th, 1872, for Wemyss Bay, and which carried Mr. Westinghouse himself and a large party of railway engineers and officials. Two features of the system received our especial commendation, the "almost perfect" form of joint for making and braking the train pipe connections between the vehicles, and the "donkey engine pump," employed to create and maintain the supply of compressed air in the brake reservoirs. The joint, we found, could be made in ten seconds, while the pump, in spite of the fact that it had no fly-wheel, could work when required as slowly as one stroke per minute. We were also impressed with the introduction into the system of a whistle, whereby the guard and driver of a train fitted with the Westinghouse brake could signal to one another. Another novelty—we definitely described it as such—was the use of cast iron brake blocks to which Mr. Westinghouse had introduced us. Such blocks had been employed in the United States for some years, and we urged railway engineers in this country to get rid of the false idea that "they would not do," and to abandon wooden blocks in their favour. Although the Westinghouse brake was subsequently improved and modified in many of its details, all its principal features were present in the original form, as illustrated in our pages. It is doubtful, in fact, whether any invention of a major order was ever born in a more complete state than that which characterised the early Westinghouse brake. To-day the Westinghouse brake is employed on the Southern Railway's electrified stock and on the Isle of Wight Railway, but elsewhere in this country—and to a large extent in the Dominions and India and on the South American railways associated with British interests—the vacuum brake is, or is becoming, the standard system. Abroad, however, the Westinghouse brake fully retains its popularity. In the principal European Continental countries it is still standard, while in the United States and Canada it is in use on virtually all railways.

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W. 1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

SYMBOLS FOR ELECTRICAL WIRING.

No. 447—1932. These standard symbols have been drawn up with the co-operation of the Architectural Association, the Association of Consulting Engineers, and the Electrical Contractors' Association. They enable complicated installations to be drawn without resorting to the use of coloured pencils or ink, and without covering the plan with a maze of letters and figures. In drawing up the symbols consideration has been given to the employment, where practicable, of a sign which has some slight resemblance to the device it is intended to represent and which, by slight modification, can be used to indicate various special uses of the device. The symbols are conveniently arranged on a single sheet which can be cut out of the booklet and stuck on a card for hanging on the wall. Price of this specification, 1s. 2d.

RADIO VALVES AND SOCKETS.

No. 448—1932. Prior to the meeting of the International Electrotechnical Commission in September, 1927, there existed two slightly divergent sets of dimensions for radio valve bases, those adopted in Great Britain on the one hand, and those adopted by the majority of the countries on the Continent of Europe on the other hand. These two sets of dimensions were just sufficiently divergent to prevent complete interchangeability. At the meeting referred to, a compromise was suggested whereby complete interchangeability could be secured by making a slight alteration to both sets of dimensions. That compromise has been adopted by the British Standards Institution, with the agreement of the Radio Manufacturers' Association and the Valve Manufacturers' Association.

Railway and Road Matters.

AFTER having named a series of locomotives after the "Shires" and the "Flying Scotsman" class after famous race horses, the fifteen three-cylinder, 4–4–0 express passenger engines now being built by the London and North-Eastern at Darlington, are to bear the names of famous hunts in the area served by that company. As there are seventeen hunts, two of the "Shire" class are to be renamed.

ACCORDING to the *Great Western Railway Magazine* for May, the average miles per hour for that company's freight trains over the whole of the system during the four weeks ended March 12th, 1932, was 7·6 m.p.h., an increase of 0·4 m.p.h. over the corresponding period of 1931. It is added that it may be of interest to record that, in pursuance of the company's policy of accelerated express freight train working, over 1200 vacuum freight trains were run during the period in question at speeds, including all stops for shunting and other work, of 20 m.p.h., the running speeds in many cases being 40 or more m.p.h.

ADDRESSING the West Hartlepool Chamber of Commerce on May 10th, Mr. Whitelaw, chairman of the L. and N.E.R., went farther, as to an agreement with the L.M.S.R., than he did, as reported on page 509 of our issue of May 9th, at the Railway Benevolent Institution dinner. He said on this later occasion that the two companies were going to the Minister of Transport to ask permission to pool competitive traffic and carry goods by the shortest and cheapest route. We may add that since the Railways Act, 1921, such agreements have to be submitted to the Minister, as otherwise, under Sec. 19, "it shall not be lawful for any . . . company, without the consent of the Minister, to enter into agreements . . . for the allocation of traffic or the pooling of receipts or otherwise for effecting a combination . . ."

THE Board of Trade export tables for March show the value of the railway material sent overseas during the first three months of the present year to have been as follows; the corresponding figures for 1930 and 1929 are added in parentheses:—Locomotives, £119,383 (£655,886, £851,486); rails, £56,579 (£254,196, £729,964); carriages, £72,577 (£562,886, £433,155); wagons, £93,008 (£338,102, £760,885); wheels and axles, £42,369 (£47,282, £87,166); tires and axles, £44,252 (£93,101, £179,260); chairs and metal sleepers, £49,397 (£50,686, £200,462); miscellaneous permanent way, £57,688 (£143,124, £226,358); total permanent way, £262,713 (£605,770, £1,459,650). The weight of the rails exported was 6137 tons (30,265 tons, 84,787 tons) and of the chairs and metal sleepers, 5785 tons (5223 tons, 20,508 tons).

THE Ministry of Transport railway statistics for the four weeks ended February 27th last have recently been published as a Stationery Office publication, price post free 2s. 7½d. The number of passenger journeys and the receipts from passengers are for the month of February and are therefore influenced by the extra day, due to 1932 being a leap year. The journeys, when compared with February, 1931, show a decrease of 1·6 per cent. and the receipts from passengers a drop of 5·3 per cent. For the four weeks only the passenger train mileage decreased by 0·8 per cent. The tonnage of freight, also for four weeks, decreased by 4·6 per cent., and the receipts 6·4 per cent. Freight train mileage was brought down by 5 per cent. The average train load was increased from 126½ to 127 tons, and the net ton-miles per engine hour from 445½ to 456.

THE provisional returns of railway accidents and casualties during 1931 show that 203 collisions and the same number of derailments were reported, compared with 242 collisions and 173 derailments in 1930, and 281 collisions and 235 derailments in 1929. There were 6342 failures of rolling stock or permanent way, compared with 7022 in 1930 and 8805 in 1929. Eight passengers and thirteen servants were killed in train accidents. In "movement" accidents 146 servants lost their lives, as against 204 in 1930 and 205 in 1929. But while this last is a gratifying reduction, the number of servants injured in "movement" accidents did not fall in proportion, as that figure was 2633 as against 2874 and 3170 in the preceding two years. The decrease in the number of failures of rolling stock was almost wholly caused by coupling failures, dropping from 6676 to 5935.

THE Gersenialp-Trübsee Aerial Railway Company inaugurated its services in 1927 with, at that time, up-to-date equipment designed on the Bleichert system. Soon after the line was set in operation it became apparent that the number of passengers which the cars were designed to carry—fifteen passengers plus conductor and luggage, or eighteen persons without luggage—was too small to cope with the rush-hour traffic. The question of the increasing carrying capacity, however, was one of difficulty, since any alteration involving changing the installations, the landing-stages at the valley and mountain stations, the mast supports, cables, &c., would have involved very great expense. The company therefore decided in the early part of 1931 to build new cars of a copper-aluminium alloy. The new cars, which weigh 1300 kilos., as against 1720 kilos. of the steel cars, have now been in use for some three months, and are reported to be entirely satisfactory.

THE report of the Railway Commissioners of New South Wales for the year ended June 30th, 1931, recently received by us, shows that compared with the year 1929–30 the receipts decreased by £2,620,951, whilst the expenditure was reduced by £2,062,777. The reference to the losses resulting from motor competition alluded to the passing of a State Transport (Co-ordination) Act. The adverse influence of bad trade is illustrated by the statement that there were 130,000 unemployed in June, 1931, as compared with 52,500 in June, 1930. Evidently the administration has been criticised, as the report observes that "the persistence of uninformed criticism as to the causes of the falling off in railway revenue makes it necessary to emphasise the plain fact that less trade means less goods traffic, less employment, and reduced purchasing power means less travel, and these factors react upon one another so as to make a whirlpool of depression into which the railway is drawn."

Notes and Memoranda.

A PORTABLE surge generator suitable for use in the field as well as the laboratory, has been put into service by the Duquesne Light Company, of Pittsburg, U.S.A. The apparatus is mounted on a truck and consists of a rectifier and transformer, enabling banks of condensers to be charged from a 110-volt A.C. supply. The apparatus is rated at 750 kV, with a capacity of 0·0145 micro-farad. The condensers are connected in the usual Marx circuit, whereby they are discharged in series by means of interconnected spheres. The breakdown of one gap throws increased potential on the next gap, which forthwith breaks down. The breakdown action propagates through the entire system of condensers in less than a millionth of a second.

THE dust collected on the Chilean slopes of the Andean volcañoes Quizapu and Descabezado, after the eruptions on April 11th–12th, and sent to *The Times* by air mail, was placed at the disposal of the British Museum, which reports: A preliminary examination of the dust, which is almost pure white, shows it to consist mainly of fragments of pumice and nearly colourless volcanic glass, mixed with chips of felspar, brown hornblende, augite, and magnetite, all in rather small amounts. The size of the dust particles varies from one-fifth of a millimetre (0·0078in.) downwards, the most frequent size of the mineral chips being about one-tenth of a millimetre (0·0039in.). Its composition shows that it could have been formed by the shattering of a glassy hornblende-andesite or dacite.

TO corroborate many facts already known about corrosion and to explain others, the Westinghouse Research Laboratories have built a device which greatly hastens the slow process of rust. According to *Power*, the test specimens are subjected to intermittent immersions in a corroding liquid. The apparatus suddenly immerses the samples for a definite period, leaving them at rest and then removing and exposing them to air for a definite period. They are moving only when being lowered or raised—a time which is a very small fraction of the cycle. Samples are suspended from a rack by glass hooks, horse hair, or silk, and a motor-driven crank shaft raises and lowers the rack. The driving motor is controlled by a timing device composed of a synchronous motor operating a contact which causes the motor to turn the crank shaft a half revolution periodically. The timing can be set for any cycle of test operation. To obtain reproducible results the corrosive liquids are kept at a constant temperature by circulating water along the outside of the vessels containing the corrosive liquids.

ELECTRICAL conductors of pure aluminium, states Mr. F. R. F. R. Dallyn, in an article in *Power*, have been in use in the United States since about 1898. Stranded cable was the first product commercially available and only a few years elapsed before aluminium was being fabricated in the form of bars or rods and used for bus-bars in industrial plants. To-day, aluminium electrical conductors for bus construction are used in three major forms—flat bar, tubing and structural shapes, the last including channel sections, angles, and other shapes. Flat bar is by far the most commonly employed for both A.C. and D.C., on switchboards, in sub-stations, and in industrial plants. Flat bars are easy to form, as well as simple to join and support. Over comparatively narrow ranges, current capacity may be increased by the addition of bars in multiple. On the other hand, flat bars offer little resistance to bending in the plane perpendicular to the major axis of the cross section. They are relatively inefficient for transmitting heavy currents unless special configurations or interlacing are resorted to, in which case the support fittings become somewhat complicated and expensive.

IT is reported that many new and attractive features are incorporated in London's most up-to-date tramcar which will shortly make its appearance on the Kingsway subway route. The new vehicle has been built at the London County Council's Charlton Works as an experiment, and, if tests are satisfactory, other cars of similar design will be constructed. A pleasing blue and white finish is used for the exterior and a stream-line effect is obtained by building into the body the portions that project on the standard car. Instead of the usual destination boards on the sides, rectangular illuminated indicators are employed. Inside blue is also predominant in the colour scheme of the seats, all of which are of the armchair pattern. Accommodation is provided for twenty-eight persons inside and thirty-eight on the upper deck. Diffused lighting is obtained by means of 40-watt lamps concealed behind frosted glass panels. Sixteen Siemens tubular heaters, 4ft. long, have been installed along the sides of the car between the seats. Electrically operated "Faraday" warning bells are also used. The new vehicle is driven by four 35 H.P. motors, and has a maximum speed of 30 m.p.h., with an acceleration of 3·5ft. per second per second.

THE condition of the air in the tunnels at Blackwall and Rotherhithe has been the subject of study by the chemical staff of the London County Council, determinations of carbon monoxide, suspended matter, and the relative humidity having been made during a period of nearly two years. In addition, determinations of the sulphur impurities were made from time to time by members of the staff of the Government Chemist, using the methods recently devised for the Committee on Atmospheric Pollution. Under normal conditions of traffic, the highest concentration of carbon monoxide found in these tunnels was 3·1 parts in 10,000 of air, but on the occasion of a severe traffic block caused by an accident at Blackwall a value as high as 11·5 parts in 10,000 was obtained. During the period covered by the tests, extraction fans were installed at one position at Blackwall, whereupon an improvement in the condition of the air at that place was observed. From the work of Haldane, Douglas, and Hartridge in Great Britain, and of Henderson and his co-workers in the United States, it may be concluded that no appreciable physiological effect is produced by carbon monoxide in concentrations not exceeding 3 parts in 10,000 of air when breathed for one hour.

Miscellanea.

ON Saturday, May 14th, the B.B.C. said farewell to its old headquarters in Savoy-hill and moved on to the palatial new Broadcasting House.

HENRY FORD is reported to have made a bid for three 60-kW, 120-volt generators built by the American General Electric Company in 1891, after Edison's design, for the Mills Building, San Francisco, where they have just been put out of operation.

THE Russian electrical journal *Electritchestvo* says that the Soviet Government plans to erect a transmission line between Svire, Leningrad, and Dnieprostoi to transmit power at a potential of 400 kV. Leningrad is about 800 miles from the site of the plant.

SYMBOLS for use in the fields of mechanics, structural engineering and materials testing have been approved by the American Standards Association. The list was prepared by a special committee, organised in 1926, on which the Society was represented by the Assistant Secretary.

IT is reported that the L.M. and S. Railway is considering the Weir report on the electrification of railways, and among the schemes which have been proposed are electrification of the main line from London to Carlisle branch sections to Birmingham and branches in the North, including the line from Manchester (Victoria) to Blackpool.

IT is reported that the engineers connected with the Transport Department of Glasgow Corporation will shortly issue their report to the Transport Committee regarding the electrification of the Glasgow Subway. The estimated cost of the change-over from the present rope drive is from £70,000 to £80,000, and it is considered that the electrification will save between £20,000 and £30,000 per annum.

RECENTLY Sir John Snell received a joint deputation from the Electrical Association for Women and the National Federation of Women's Institutes to discuss the question of countryside electrification from the woman's point of view. Sir John outlined the present position with regard to rural development, especially in connection with the Bedford and Norwich schemes. The deputation was the result of considerable co-operative work carried out recently between the Electrical Association for Women and the Women's Institutes.

APART from a reduction from 102,095 tons to 87,267 tons in shipments from Hull, Immingham, and Grimsby, there was a general increase in British coal shipments last week, compared with the previous week. The total was 29,540 tons higher from Wales at 319,810 tons, 40,954 tons higher from the Tyne, Blyth, Wear, and Hartlepools, and 1350 tons higher from Scotland at 240,230 tons. Scottish shipments showed a considerable expansion —31,071 tons—compared with a year ago, but those from other centres continued to lag behind the 1931 level.

IT is reported by the National Federation of Iron and Steel Manufacturers that there were sixty-nine blast-furnaces in operation at the end of April, three having ceased operations for relining since the beginning of the month. Production of pig iron in April amounted to 316,900 tons, compared with 335,600 tons in March and 323,200 tons in April, 1931. The production included 61,500 tons of hematite, 137,800 tons of basic, 96,900 tons of foundry, and 13,700 tons of forge pig iron. The output of steel ingots and castings amounted to 433,300 tons, compared with 462,800 tons in March, and 397,400 tons in April, 1931.

A NEW method of degreasing condenser tubes and similar surfaces has just been introduced. Briefly, the *modus operandi* is to connect a vaporiser to the bottom of the empty condenser. A solvent is then heated by steam coils and vaporises at 186 deg. Fah. The vapour ascends and on reaching the cold tubes condenses, and the reliquefied solvent dissolves and removes the grease deposits. Dropping back, the grease-charged liquid is revaporised, but the grease, having a much higher boiling point, remains in the vaporiser sump and is not, therefore, redistributed. The Atlas Preservative Company, Ltd., of Erith, is operating the process.

PRESIDING at the annual meeting of the National Gas Council of Great Britain and Ireland in London, Sir David Milne-Watson, governor of the Gas, Light and Coke Company, said the country must be warned seriously against going over to oil as the fuel of the future. "We live very largely," he said, "on imported foods, and if we are to live on imported oil, well, God help this country. It seems to me that it will be simply doomed, because not only will the coal industry suffer, but the railways also. The best way to counter oil is with gas. We have to see that gas is supplied for every purpose for which oil is used, in such a way and at such a price that oil will be kept out." Modern buildings, he said, had no place for raw coal, and needed something that was clean and easily controlled. Thermostatically controlled gas required no labour or storage.

A REPORT has just been published by H.M. Stationery Office on the proceedings at the International Conference on Safety in Mines, which was held at Buxton in 1931, and was attended, at the invitation of the Safety in Mines Research Board, by ten representatives of the Belgian, French, German, and American mine safety research organisations. The safer use of mining explosives was chosen as the principal subject for discussion, on account of the importance of the problem and of the investigations thereon carried out in each of the countries represented. Addresses were given on "Simultaneous Shot Firing: the Position in Belgium," by Ad. Breyre, Belgium; "The Testing of Explosives," M. Audibert, France; "Investigations on the Igniting Power of Explosives," by E. Beyling, Germany; and "The Application of Schlieren Photography in Researches on Explosives," by W. Payman, England. These papers are reprinted in the report and the discussions upon them are given. At the conclusion of the conference, tentative arrangements were made for future general international co-operation on safety in mines research, subject to ratification by the organisations concerned.

PRETTYBOY DAM—ROCK CUTTING WITH WIRE ROPES

(*For description see page 553*)

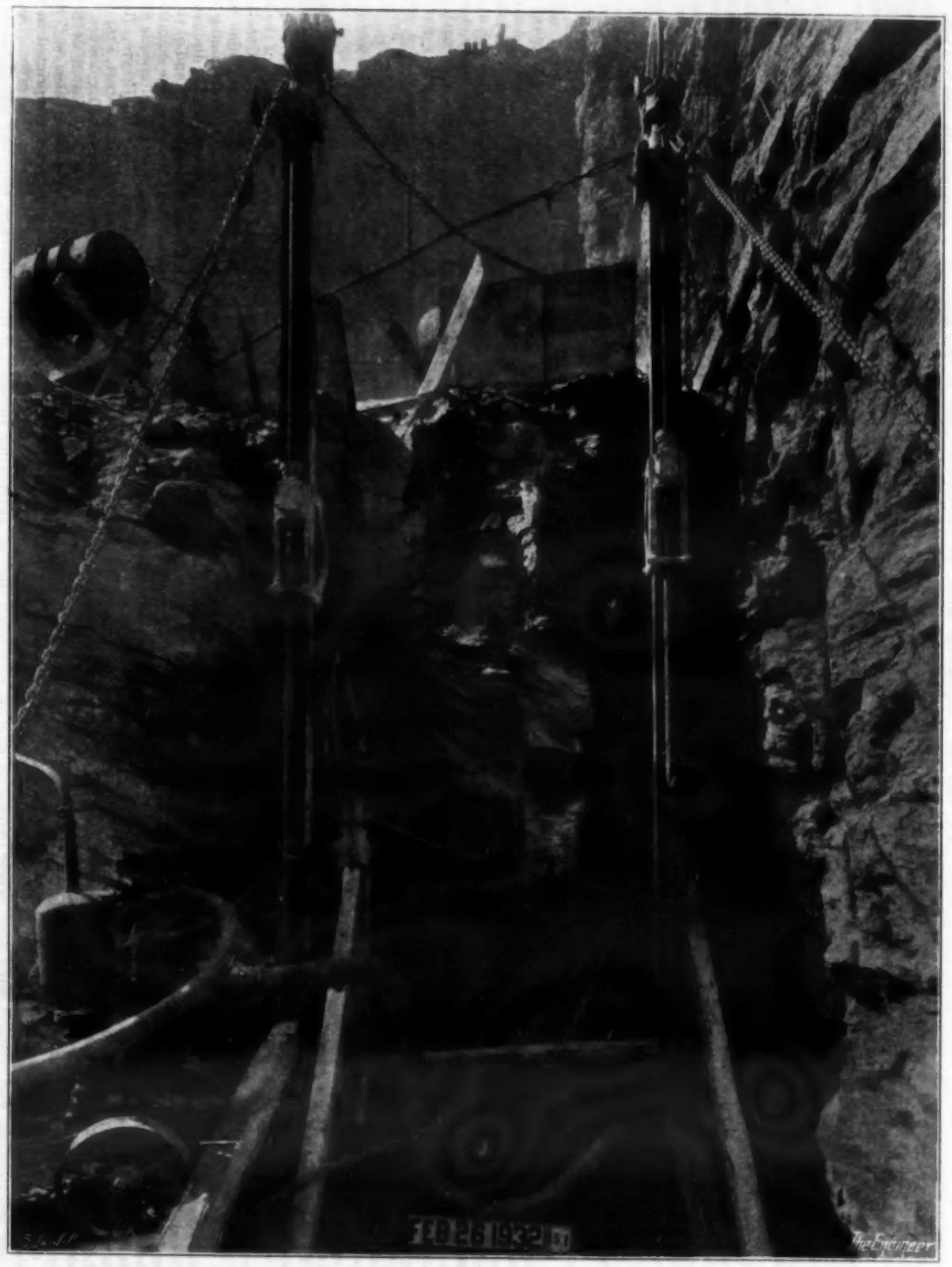


FIG. 2—TENSION POSTS IN POSITION

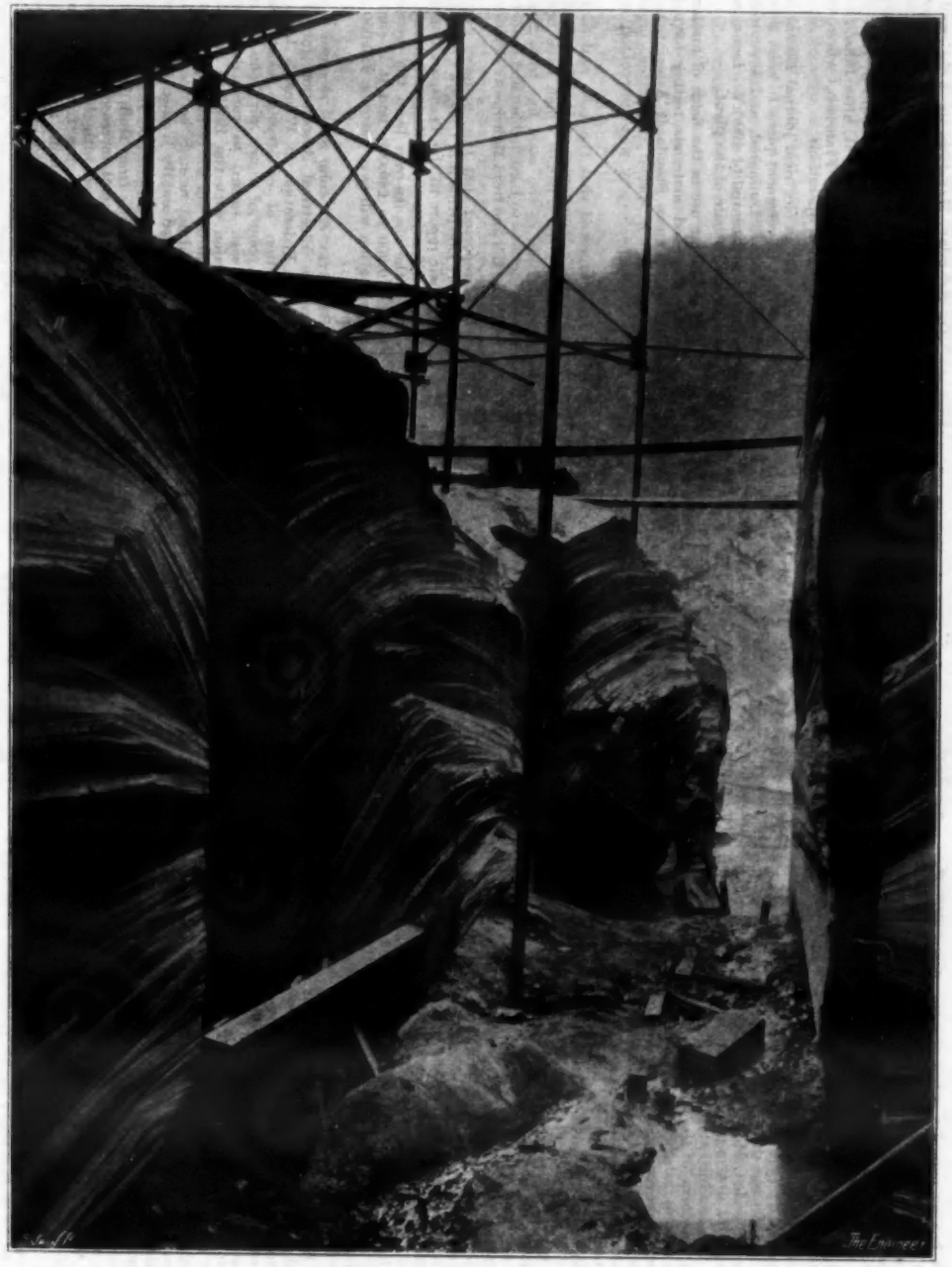


FIG. 3—FACES OF ROCK CUT BY WIRE ROPE

The Engineer

MAY 20, 1932.

VOL. CLIII. No. 3984

Contents.

THE ENGINEER, May 20th, 1932. PAGE

A SEVEN-DAY JOURNAL .. 545
THE DETERMINATION OF WORM GEAR CONTACTS. (Illus.) .. 546
THE IRON AND STEEL INSTITUTE. No. II. .. 549
TRANSIENT VOLTAGE STRESSES IN POWER TRANSFORMERS. No. IV. (Illus.) .. 551
PRETTYBOY DAM, BALTIMORE. (Illus.) .. 553
OUTDOOR SUB-STATION LATTICE STEEL STRUCTURES. (Illus.) .. 554
SCHOLARSHIPS IN ELECTRICAL ENGINEERING .. 556
SIXTY YEARS AGO .. 556
BRITISH STANDARDS INSTITUTION .. 556
RAILWAY AND ROAD MATTERS .. 557
NOTES AND MEMORANDA .. 557
MISCELLANEA .. 557
LEADING ARTICLES—
Fires Aboard Liners .. 559
Electrical Troubles .. 559
RICHARD TREVITHICK .. 560
LITERATURE .. 560
SHORT NOTICES .. 561
LETTERS TO THE EDITOR—
British Locomotive Design .. 561
Atmospheric Railways .. 561
The Production of Engineers .. 561
THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS .. 562
CYLINDER LINER WEAR. (Illus.) .. 563
HAMBURG CONFERENCE ON SHIP PROPULSION .. 565
WORLD STEEL TRADE: POSITION AND PROSPECTS .. 565
A SPECIAL LORRY FOR HANDLING PIPES AND BAR MATERIAL. (Illus.) .. 566
SMALL POWER TRANSFORMERS FOR 132-kV CIRCUITS. (Illus.) .. 566
AMERICAN ENGINEERING NEWS .. 566
A NEW FORM OF FIRE-GRATE FOR LANCASHIRE BOILERS. (Illus.) 567
PROVINCIAL LETTERS—
The Midlands and Staffordshire .. 567
Lancashire .. 568
Sheffield .. 568
North of England .. 568
Scotland .. 569
Wales and Adjoining Counties .. 569
PERSONAL AND BUSINESS ANNOUNCEMENTS .. 569
CONTRACTS .. 569
CATALOGUES .. 569
CURRENT PRICES FOR METALS AND FUELS .. 570
FRENCH ENGINEERING NOTES .. 571
BRITISH PATENT SPECIFICATIONS. (Illus.) .. 572
FORTHCOMING ENGAGEMENTS .. 572

NOTICES TO READERS.

**** If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

**** For Subscription rates see page 2 of Advertisements.*

**** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

FIRES ABOARD LINERS.

WE would extend our deep sympathy to the French owners of the ill-fated luxury liner "Georges Philippar," and to all those who have suffered personally or indirectly as a consequence of her loss by fire in the Gulf of Aden on Monday last, May 16th. The principal technical particulars of the ship are given elsewhere in this issue. She was only commissioned late last year, and her design, we believe, embodied the latest improvements in passenger accommodation with every possible refinement which might ensure her safe navigation and her protection against damage by fire at sea. Full details of the disaster have yet to reach us, but from the news already to hand it would appear that the fire, which gained so firm a hold in so short a time, either originated in or gained access to the upper structure of the ship, where it quickly put out of use the wireless apparatus, and damaged some of the lifeboats.

This deplorable accident, taking place as it did after several recent outbreaks on ships, either under construction or repair, or while at their berths, will focus renewed attention on the problems of protection from fire for both passenger and cargo ships. We may recall the small outbreak of fire on the "Statendam" during her construction, which did but little harm, and the more serious fire on the "Europa," which caused great damage. More recent fires were two on the "Bermuda," leading in the second case to her total loss, and that on the L.M.S. steamer "Duke of Lancaster," which practically destroyed the ship just before she was scheduled to sail. In all these cases the outbreaks appear to have originated in cabin spaces where conditions are such that once the fire has obtained a good hold, the accompanying smoke and the great difficulty of getting at the seat of the conflagration make the task of confining and extinguishing it an extremely difficult one. The risk of fires in cabins and state-rooms would be greatly lessened by the increased use in them, where possible, of impregnated fire-resisting wood and the adoption of metal-clad plywood and metal furniture and fittings, which articles, it is well known, can be finished either to resemble wood or in decorative styles. When at sea the use of ventilating fans and air supply systems increases the danger of a fire getting a hold, and a master switch might well be fitted on the bridge, which, on the sounding of the fire alarm, would allow all fans to be instantly stopped. The newly revised International Merchant Shipping Act, which comes into force in November of this year, the provisions of which also apply to all ships now under construction, makes it obligatory for owners to fit an automatic fire alarm device as well as to maintain a fire-patrol service and to provide adequate means for extinguishing fires. In addition to the above-mentioned provisions, stringent regulations have been laid down covering the fitting of fireproof bulkheads and fire-resisting doors in all machinery and accommodation spaces, together with adequate pipe systems, hoses, and chemical fire appliances. In the case of cargo holds and coal bunkers, fires have been greatly reduced in recent years by approved preventive methods, which have been applied in modified forms on most modern passenger liners. These include systems for drawing air continuously from each of the various holds or compartments to a central control board on which by properly arranged illumination the presence of smoke in any compartment is at once detected. More recent devices utilise the selenium bridge, while in some cases a resistance method, involving the breakage by heat of a small glass element, thereby changing the resistance of a circuit, have been found effective. All such detecting devices, however, are useless without the additional provision of manually or automatically operated gas or chemical extinguishers. In contrast to such methods, the more direct sprinkler system has been installed on a few ships, and in view of its successful and extensive use in factories, mills, and hotels, it would seem to warrant further consideration on the part of ship designers, although the conditions are very different, the general lack of deck height in state-rooms introducing a new factor in efficient water distribution which is not present in public rooms and machinery spaces. Happily, serious fires at sea in British ships are comparatively rare, the last being that on the "Volturno" in 1913.

From what has been said, it will be seen that every effort has been made on the part of naval architects and engineers, and by the Board of Trade authorities to reduce to the minimum the possibility of an outbreak of fire at sea, even at the expense of increased cost to the shipowner. When in the shipyard, special precautions are always in readiness, with a strict patrol service, especially in the off hours. At sea the same precautions cannot be taken without interfering with the privacy of passengers. The likelihood of fires being caused in service by failures in electric circuits is, we think, a comparatively rare one, in view of the very careful design of ships' electrical fittings and the improved insulation of cables. The possibility of the human element in the carelessness of passengers cannot be overlooked, there still being some passengers, we regret to say, who, when aboard ship, are not so careful of avoiding fire risks as they undoubtedly would be in their own homes. The necessity of such care should be impressed on all who travel by sea. In conclusion, we would say that British underwriters will take a keen interest in any means which may be devised or measures which may be taken to lessen fire dangers aboard ship, as in recent years they have been called upon to bear a heavy share of the damage resulting from such accidents, both on British and Continental liners.

Electrical Troubles.

OF the many articles and papers dealing with electrical subjects, only a small proportion refer to engineering troubles. The uninitiated may well imagine that all the problems associated with the generation and supply of electricity have been completely solved and that new plant invariably meets expectations. Manufacturers are generally the last to talk about their difficulties, even when they have been overcome. House journals contain many accounts of important work carried out in this country and elsewhere, but rarely is any reference made to unexpected troubles. The contractor generally prefers to discuss his competitors' misfortunes rather than his own. On the supply side of the industry there is a tendency to leave the reasons for occasional interruptions in the service unexplained, and reports that appear in the daily Press are generally incomplete or inaccurate. Supply undertakings are more inclined to send out particulars of the growth of load, extensions to plant, and increased revenue than they are to furnish information about occasional breakdowns. Even the reports of the Central Electricity Board give no clue to anything in the nature of real trouble. Judging from these reports, practically everything has worked smoothly. Wayleave difficulties have apparently disappeared; people seem to have developed a liking for the sight of "grid" towers, and have begun to enjoy transformer hum. Experience of the "grid" in the Central Scotland area, states the last report of the Board, has called for few technical modifications, and apart from one or two operational mistakes inseparable from the initial handling of plant of new type, operation has been satisfactory. But it would be of interest to many to know exactly what technical modifications have been necessary. Notwithstanding all the brains behind it, no one imagined that the "grid" would go into operation without a hitch. Perhaps at some future date official publications will throw more light on the nature of these modifications. Meantime we note with interest that the Board has recently placed orders for three harmonic absorbers for use on the Scottish section of the "grid" where harmonic troubles are presumably being experienced.

Accounts of troubles make interesting reading and greatly add to the value of technical reports and papers in which they appear. They also serve to show that, contrary to the belief of the uninitiated, an engineer's job is not easy. Many descriptions of engineering contracts are apt to give the impression that the work has been child's play, whereas as a matter of fact all sorts of difficulties may have been met with. Despite long experience and great technical ability at their disposal, contractors may still meet with pitfalls. Local conditions may easily influence results and call for modifications which no one contemplated at the outset. As shown in Mr. F. Lydall's recent paper on the electrified lines of the Great Indian Peninsula Railway, for example, when operation was begun birds caused many severe short circuits on the transmission lines and the overhead equipment of the track. They built nests of iron wire in the braced corners of overhead line structures, and special features had to be introduced into the design of the track equipment in order to eliminate the trouble. Insects and vermin also infested the sub-stations. Short circuits caused mainly by crows subjected the converting plant to very severe treatment and considerable damage was done to the commutator risers. The most serious breakdown recorded in the paper, however, was not due to local peculiarities, but was caused by a 1500-volt circuit breaker failing to clear the arc formed on opening. The consequent damage to the auxiliary circuit connections in the cubicle caused the two machines forming the 1500-volt set to lose their excitation, the H.T. switch opened, the armatures stopped, and then ran away in the reverse direction of rotation. The obvious conclusion to be drawn from this experience is that circuit breakers and auxiliary circuits are best apart. Precautions have, of course, been taken to avoid recurrences of all the early troubles, but credit is due to Mr. Lydall for describing them. Other engineers who may have to undertake similar work may now realise better than they did before that birds, insects, and vermin may prove a far greater nuisance in distant parts than they do in this country. Of all the unpleasant things that can happen in a generating station or sub-station nothing is worse than that of a machine attaining excessive speed. Electrical engineers do not need reminding that serious accidents of this nature have occurred. Power station buildings have suffered considerable damage and members of the staff have been killed, but it is some time now since a catastrophe of this kind was recorded. Although when plant is running in parallel with other synchronous machinery speed is, of course, fixed by the frequency of the system, under other conditions the possibility of racing is less remote. In the case of rotary converters running independently on the A.C. side and drawing their supply from a D.C. system, speed is governed by field strength, which is reduced by lagging currents in the armature. Early experiences pointed to the desirability of providing devices for cutting out rotaries in the event of excessive speed and a special excitation system for inverted operation was designed to keep the speed constant irrespective of lagging loads. But while these devices have proved efficacious and there have been few cases of inverted rotaries running away, Mr. Lydall's paper indicates how important it is to ensure that auxiliary circuits are properly protected.

Of the few papers bearing on operating problems

read before the I.E.E. within recent years, one of the most useful was Mr. H. B. Poynder's contribution on "Some Practical Considerations in the Design of Automatic Equipments for Heavy Duty Traction Sub-stations." Setting aside convention, the author pointed to some of the shortcomings of existing designs and indicated directions in which improvements might be made. Again, Mr. R. J. Ryle's paper dealing with "Suspension Insulators for Industrial Areas in Great Britain" was a contribution which engineers who are operating lines in polluted atmospheres could scarcely fail to appreciate. Another paper that was probably equally welcome to some transmission engineers was that on "Surge Investigations on Overhead Line and Cable Systems," presented by Messrs. S. W. Milsom, A. N. Arman, and W. Bibby. More papers bearing on operating troubles and more attention to such matters in discussions would be beneficial. When asked at a recent I.E.E. meeting whether he would care to say anything about his switchgear experiences, a well-known engineer replied: "I dare not, Mr. President." But modern electrical engineering is the outcome of the experience gained by many false steps, and even in these days of great achievements it is highly undesirable that records of unsatisfactory performances should be suppressed.

Richard Trevithick.

By H. W. DICKINSON.

A STATUE of Richard Trevithick, the great civil engineer (1771–1833), was unveiled at Camborne, Cornwall, on Tuesday last, the 17th inst., by H.R.H. Prince George, K.G. Thus has been brought to fulfilment a project upon which a small band of enthusiasts has been engaged for twenty-one years. Interrupted first by the war and then set back by the increase of costs subsequent to it, coupled with depression in the mining industry, it has needed dogged perseverance to raise the necessary funds. We can but congratulate the Trevithick Memorial Committee on the outcome—a statue which must meet with the applause of the whole engineering profession.

It is perhaps invidious to suggest that as the memorial has been so long under weigh, it would have been appropriate to have deferred the unveiling just a little longer, *i.e.*, till next year, when the centenary of Trevithick's death could have been made the occasion of the ceremony. However, it is a great satisfaction to know that the labourers' task is done, and that at last there is in existence a fitting monument to the great engineer, and likewise to a great Cornishman. It should be added that to Cornish men and women this happy issue is largely due.

It is true that there is already a memorial to Trevithick, in the form of a stained glass window in Westminster Abbey, erected by public subscription as the outcome of the commemoration of the fiftieth anniversary of his death; but it is sad to reflect how few engineers visit the Abbey and of these how few see the window. The statue that has just been unveiled, in front of the Public Library at Camborne Cross—the position originally selected and adhered to after protracted discussion—cannot fail to arrest public attention in a way that a window does not do.

There are other lesser memorials to Trevithick, and we recall the bronze tablet in Dartford Parish Church, Kent, erected in pious memory by a well-known engineer there, to tell the visitor that in the neighbouring churchyard rest the mortal remains, unmarked even by the swelling of the sod, of one of the greatest mechanical geniuses the world has seen.

If we mention the wall tablet in Camborne itself to commemorate Trevithick's first experimental steam carriage on a common road, tried there in 1801, we shall have almost exhausted the tale of such memorials. Hence the significance of the present statue.

It is of bronze, greater than life size, and depicts Trevithick holding in his left hand a model of the road locomotive referred to above and pointing to it with his right, while he gazes towards Beacon Hill, the scene of the trial on Christmas Eve, 1801. His attitude, with feet firmly planted slightly apart, gives an impression of the physical strength which he possessed in an extraordinary degree, while the expression on his face, based on the well-known portrait by J. D. Linnell, conveys the impression of intellectual vigour with which he was so uncommonly endowed. In short, his greatest achievement—the introduction of the high-pressure engine—is symbolised, and by this the present generation must understand the engine worked by steam above atmospheric pressure, as contrasted with the then existing cumbrous low-pressure engine, which depended on the vacuum produced by the condensation of steam below the piston. No sooner had Trevithick got hold of this idea of high pressure than he made its most important application, that to locomotion, for which the low-pressure engine was obviously impracticable.

On the base of the statue is the single word "Trevithick." The whole stands on a well-proportioned plinth of Cornish granite, on all four sides of which are bronze panels. Those on the sides and front are in the form of female allegorical figures indicating Trevithick's inventions. On the front panel the figure holds a Cornish boiler; on the panel on the left the figure holds a model of the Merthyr Tydvil rail locomotive of 1803, whilst a recent modern locomotive is shown for contrast. In the panel on the right the figure holds a model of his dredger of 1805, while a modern liner fills in the background. The fourth panel on the back shows a ship with the sun rising behind it, occupying the centre, with on the right Carn Brea, to typify Trevithick's birthplace; and on the left is the mule track, 15,000ft. up, over the Andes of South America, by which his high-pressure engines were taken from Lima to Cerro de Pasco mines in 1816, on the ill-starred venture that shed ten of the best years of Trevithick's life and left him at the end penniless and broken in health. Here appear the words "Richard Trevithick, inventor of the locomotive engine. Born 1771, Died 1833."

The statue was commissioned in 1917 from Mr. Leonard S. Merrifield, the sculptor, himself a West Country man. He exhibited a model in the Royal Academy Exhibition of 1918, but it was ten long years before the Committee was in a position to order the statue to be cast. Mr. Merrifield is heartily to be congratulated on his sympathetic and understanding treatment of his subject. He who will take the

RICHARD TREVITHICK

trouble will see, not only a statue, but will read a life story—a consummate artistic achievement.

At the luncheon preceding the unveiling, held at the Camborne School of Metalliferous Mining, by invitation of the Governors, H.R.H. Prince George paid a generous tribute to the great inventor and the influence of his inventions on succeeding generations, and based upon them a call to the youth of the country to follow in his footsteps.

The sole toast, following the Royal ones, to "The Immortal Memory of Richard Trevithick," was proposed by Mr. W. Pellew Harvey and seconded by Mr. Isaac Foot, M.P. for Bodmin and Minister of Mines. The Lord Lieutenant of the county, Mr. J. C. Williams, was in the chair.

The unveiling took place in the afternoon, as part of a long day's programme of visits to institutions and works. His Royal Highness was received by the Chairman of the Urban District Council, Mr. J. F. Odgers, supported by the Councillors and the Trevithick Memorial Committee. Only two of the original Committee, Mr. T. Knowles and Mr. W. Cox, survive. Thousands of people were able to see the ceremony performed, and brilliant sunshine favoured the proceedings.

It ought to be mentioned that, beside the erection of a statue, the aim of the Committee was to found a Trevithick Mining Scholarship at the School of Mining. This was successfully accomplished in 1923 and comprises free instruction and £30 for maintenance per annum.

IN the refinery of a Scottish aluminium company, states *Industrial Gases*, a process is being developed for the coating of chill moulds with carbon deposit from the acetylene flame. A flame up to 18in. in length is required from a blow-pipe nozzle slightly flattened to form an oval orifice. The flame is in constant use for fifteen to twenty minutes every four hours.

Literature.

Advanced Mechanics of Materials. By FRED. B. SEELY, M.S., Professor of Theoretical and Applied Mechanics, the University of Illinois. London: Chapman and Hall. 1932. Price 31s.

THIS book deals with some aspects of the subjects of strength of materials and theory of structures.

The author begins by pointing out that many of the formulæ commonly used by engineers are only approximately true in practical working conditions. The limitations of some of these formulæ are discussed, and the necessity is emphasised of using them with care in cases where distribution of stress is likely to be irregular.

The effect of combinations of shearing and direct stresses at a point in a material is considered and the ellipse of stress theory is well treated. The first section of the book closes with an excellent *résumé* of the various theories of the cause of breakdown of the elasticity of a material.

In the second section of the book several special problems are treated very fully and with exceptional clarity. These problems deal with thick cylinders, beams of unsymmetrical sections, curved beams, strength of flat plates, and torsion of non-circular sections. The design of a thick cylinder subject to external or internal pressure is worked out in considerable detail. The maximum stress, maximum strain, maximum shearing stress, and maximum strain-energy theories of elastic failure are all used, and a worked numerical example shows how different the results obtained by means of the various theories may be. It is pointed out that none of the theories is of universal application and, while the author apparently favours the maximum strain-energy theory as being more in agreement with the results of experiment, he shows that the use of any of the other theories gives results which will probably err on the side of safety.

The subject of curved beams is well treated, and the effect of curvature on the position of the neutral axis is fully explained. This chapter contains a very useful table which greatly simplifies the design of sharply curved beams, such as crane hooks, clamps, &c. The other subjects in this section are equally well dealt with.

Section three deals at considerable length with concentrations of stress due to such causes as sudden changes of section, applications of heavy loads at a point, &c. Various up-to-date methods of investigating the distribution of stress are described with many useful illustrations. Mathematical and experimental investigations of stresses at several types of discontinuity are given and the results obtained by different methods are compared and useful tables are included.

The last section of the book gives a short explanation of the principle of virtual work. The application of this principle to the determination of deflections of structures and to the solution of a number of problems dealing with statically indeterminate frames follows. Here, as elsewhere, the treatment is clear and easy to read.

An appendix dealing with various properties of areas completes the work.

A useful feature of the book is an extensive and up-to-date bibliography. The sections of this, dealing with different parts of the subjects treated in the book, are printed at the ends of the chapters and not all together. This greatly facilitates reference. A large number of fully worked numerical examples and of others supplied with answers is included.

Students should find this book very useful, as it deals with subjects more advanced than those included in the usual courses in strength of materials and theory of structures at engineering colleges. It should also prove helpful in engineers' offices.

The Electrical Educator. Edited by Sir AMBROSE FLEMING. London: Sir Isaac Pitman and Sons, Ltd. Price 72s.

PUBLISHED in three volumes and edited by Sir Ambrose Fleming, who has been assisted by a large number of specialists, the second edition of this "Electrical Educator" covers a very wide field. In all fifty-five subjects are dealt with, and although for the most part the volumes are concerned with the heavy branches of electrical engineering, the weak current side of the industry has not been neglected. Attention is paid, for example, to such subjects as television, and photo-telegraphy, wireless telegraphy and telephony, and X-rays. Atoms and electrons are discussed by Sir William Bragg, who manages to get his contribution into four pages. To the first volume, which is rather less extensive than the others, Professor Miles Walker contributes an article on the "Education of Electrical Engineers."

The power station section, naturally, introduces a lot of material that is not really electrical. There are chapters on the generation of steam, the steam engine and its testing, and steam turbines; in fact, practically everything that goes to make up a modern power station is described. Similarly, private plant for house and factory service is considered in all its aspects. Single and polyphase motors are discussed by Mr. Philip Kemp, who describes the principles of

these machines in a very able manner. Mr. Reginald Kapp deals with transformers, Dr. E. J. Teago with electric traction, and Mr. Raymond J. Mitchell with accumulator electric vehicles. Among many other notable sections is one on the testing of electrical machines by Mr. W. H. N. James. Students interested in electrical communication are catered for.

Some of the chapters make very interesting reading, such, for example, as one on "Electrical Science," by Mr. J. F. Corrigan, who deals, among other things, with the ether, and describes the well-known ether machine devised by Sir Oliver Lodge with the object of discovering whether rapidly revolving bodies would cause some displacement of the ether.

In brief, the "Educator" meets the requirements of students endeavouring to acquire a general knowledge of electrical engineering, a task which, owing to the many applications of electricity, has become somewhat difficult. Every student in these days must have some particular field in view, but a general knowledge is essential before specialisation is begun, and from the point of view of home study, this "Electrical Educator" would be hard to beat. It may, in fact, even prove useful to some engineers who occasionally find it necessary to familiarise themselves with branches of the industry other than those in which they are engaged.

SHORT NOTICES.

Hydraulics. By E. H. Lewitt, B.Sc. (Lond.), M. Inst. Aero. E., A.M.I. Mech. E. London: Sir Isaac Pitman and Sons, Ltd. 1932. 10s. 6d.—This is one of a series of text-books covering the syllabuses of the London University examination for B.Sc. (Eng.) and similar examinations. The usual theory of the flow and measurement of water is given clearly and simply, and is supplemented by many worked numerical examples. There is also a large number of questions provided with answers, which the student should work out for himself. The chapter on flow in open channels might have mentioned the Venturi flume and the phenomenon known as the "hydraulic jump." The chapter on turbines, while satisfactory within the limitations of the work, would be improved by cutting out some of the descriptions and illustrations of out-of-date machines and by replacing them with information about modern high-speed turbines, such as the Kaplan and Lawaczech. The Venturi meter has considerable space given to it, but no reference is made to the other types of flow meter using orifice plates fitted between pipe flanges which are now so widely used. For the student whose main object is to pass his final engineering examination these criticisms are not of much importance, and the book may be recommended as suitable for the purpose for which it has been written.

Theory of Machines. By Louis Toft, M.Sc., and A. T. J. Kersey, A.R.C.Sc., M.I. Mech. E., M.I.A.E. London: Sir Isaac Pitman and Sons, Ltd. 1932. Price 12s. 6d.—The theory of machines and machine design is a subject which engineering students who present themselves for the examination for the degree of B.Sc. (Eng.) of the University of London or similar examinations frequently find to be a stumbling block. This book is written to make their way as easy as possible, and those who study it carefully should find it of great assistance. It covers the syllabuses of the various examinations thoroughly, and is very clearly written. It is well supplied with worked numerical examples, and there is also a large number of selected examination questions, the source of which is indicated. There are well-written chapters on lubrication, governing and balancing of engines, and whirling of shafting. This book should prove useful not only to engineering students, but also to all those who wish to obtain a good grounding in the fundamental principles on which the design of machines depends.

Steam Boiler Construction. By E. G. Hiller. Manchester: The National Boiler and General Insurance Company, Ltd. 3s. 6d.—This useful little publication has just been re-issued in a revised form, and although the title suggests that it should appeal to the manufacturers of boilers, we feel that the information it contains is really of greater value to boiler users. Our boilermakers are conversant with their trade, and all of them produce boilers which will stand up to the standards of the insurance companies; but there are many boiler users who, through ignorance, run grave risk. It is these people that would most benefit by the reading of the booklet. It is put forward as an account of the rules which the National Boiler and General Insurance Company expects in the construction and maintenance of boilers with which it is concerned and is very explicit in connection with what are vulgarly known as "tank" boilers; but it is pointed out that in the case of water-tube boilers "practice is in a somewhat fluid condition," so that the recommendations in this direction are not so explicit. It is, nevertheless, suggested that the drums of boilers made of 28–32 ton steel should not be stressed beyond 14,000 lb. per square inch. It is noteworthy that, throughout, the reading matter is in the imperative form, but we cannot deny that it is sound and useful.

BOOKS RECEIVED.

Rubber Information. Edited by H. B. Cronshaw, B.A. London: Leonard Hill, Ltd., 231, Strand, W.C. 2. Price 10s. net.

The "Electrician" Annual Tables of Electricity Undertakings, 1932. London: Ernest Benn, Ltd., 154, Fleet-street, E.C. 4. Price 10s. net.

The Empire Municipal Directory and Year Book, 1932–33. London: The Sanitary Publishing Company, Ltd., 8, Breams-buildings, E.C. 4. Price 12s. 6d. net.

Chemical Engineering and Chemical Catalogue. Eighth edition. Edited by P. M. Newitt, Ph.D. London: Leonard Hill, Ltd., 231, Strand, W.C. 2. Price 10s. net.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

BRITISH LOCOMOTIVE DESIGN.

SIR,—When reading Mr. W. A. Tuplin's very interesting article in your issue for February 5th, I had then no time to comment on it, but there were one or two matters in it to which, at the risk of being a little tedious, I would now like to refer, but in no spirit of contradiction.

It is a common error to assume that the G.W.R. four-cylinder reconstructed 4–4–2 engine "North Star" was actually the first of the multi-cylinder 4–6–0 "Star" class. May I therefore in all friendliness and courtesy point out that the initial ten engines of that type and class were constructed at Swindon in 1907, and that the series began, *de facto*, with No. 4001, "Dog Star"? On the other hand, the "North Star" itself, which was completed in April, 1906, continued to be a 4–4–2 engine until December, 1909. It was then rebuilt as a 4–6–0, and had thus run as an "Atlantic" for nearly four years after the first of the four-cylinder 4–6–0's had been introduced. Even allowing that the "North Star" inspired the six-coupled type, the fact is that it did not fully represent standard G.W.R. practice as exemplified in the 4–6–0's, as the engine was fitted with Walschaerts valve gear of the so-called Stévart-Deeley kind, whereas all of the other four-cylinder engines had the usual pattern of Walschaerts motion. Moreover, the "North Star" retained the peculiar gear in question until as late as November, 1929, on which date the engine was converted to the "Castle" class. Incidentally, it may be added that it was not superheated as a 4–4–2, and that it was not re-numbered "4000" until December, 1912.

I cannot agree that the L.M.S.R. three-cylinder "Royal Scot" was a lineal descendant of the G.W.R. four-cylinder "North Star" of 1906. Rather was it a variant of the N.E.R. triple-cylinder express engine of 1911. Neither can the S.R. "Lord Nelson," with its 135 deg. crank system, strictly be regarded as a development of the original G.W.R. design.

The G.W.R. "Stars" are, and should be, able to tackle heavier loads than the "Saints," the respective tractive powers being 27,800 lb. and 24,395 lb. Nevertheless, the augmentation in the number of two-cylinder, 18½in. by 30in., 4–6–0's, but with 6ft. instead of 6ft. 8½in. wheels, the new "Hall" class, the tractive force of which is 27,275 lb., shows that Mr. Collett regards the type as being a very useful one. During 1928–31 120 "Halls" were built at Swindon.

With reference to the permissible limit to the size of inside cylinders with the British load gauge, it will be remembered that the former G.N.R. Vulcan Foundry four-cylinder "de Glehn" compound, "No. 1300," built in 1905, had low-pressure cylinders as large as 23in. in diameter. This engine, which was altered to a two-cylinder simple in 1917, was scrapped about six years later.

A fact worth noting is that the first of Mr. Ivatt's large "Atlantics," "No. 251"—now "3251"—which was completed in December, 1902, ran for approximately two years before the second of its class, then "No. 272," was turned out at Doncaster. The G.N.R. large 4–4–2's have demonstrated as few other British locomotives have done the value of ample boiler capacity. One of them, with a gross load, including passengers and luggage, of 570 tons behind the tender, averaged 51 m.p.h. from Potters Bar Station—to which point it was piloted—to Peterborough, the mean rate from Hitchin having been, however, 54 m.p.h. Another, hauling 510 tons gross and similarly piloted, maintained 54 m.p.h. from Potters Bar and 56 from Hitchin (passing) to the stop at Peterborough. A third, unpiloted, and with a load (full) of 430 tons, covered the 63¼ miles from Potters Bar to Peterborough at 64 m.p.h., and the 26¾ miles from Hitchin to Huntingdon at 68. These were excellent performances.

Mr. J. G. H. Warren's letter—April 29th—adds a valuable note on the subject of piston valves and valve travel—previously referred to in this discussion—from the historical standpoint. The really long valve travel, as employed to-day, was used by John Gray in 1840, in a single-wheel express engine designed by him for the Hull and Selby Railway, the valve travel having been about 6in.

F. W. BREWER.

Stevenage, Herts., May 11th.

ATMOSPHERIC RAILWAYS.

SIR,—I read with great interest the letter on "Atmospheric Railways," by Mr Dendy Marshall.

Mr. Marshall states that the system of atmospheric traction by means of totally enclosing the train in a tube has not been tried. Surely, Mr. Marshall must have heard of the Pneumatic Despatch Company. This company, founded in 1868, had offices in High Holborn, adjacent to Little Turnstile, and operated a tube railway system extending from Euston Station, L.N.W. Railway, to Holborn, and thence to the General Post Office. Its object was to convey letters, parcels, mails, &c., between the above points. After about eighteen months' working it was abandoned, though the tubes are still in position.

During 1926 the tube near Tottenham Court-road was struck during main-laying operations, and four of the original trucks were found and were presented to several institutions.

The gauge of the track was 2ft., the trucks were circular, and the wheels were "moulded," so to speak, into the body of the truck; an indiarubber washer was fitted to both ends, so that the track was really a piston in a cylinder. The air in front of it was exhausted by an engine at Euston, and the truck was propelled by an engine at the Post Office; the mode of producing power being a large wheel about 13ft. in diameter driven by beam engines.

The chief drawback was, I believe, the fact that the tubes, being cast iron and not bored in any way, were not perfect, and allowed leakage from front to back; also the rapid wear of the rubber washers. No doubt with modern methods of production these could now be produced to overcome these difficulties, but the question arises as to whether it is worth it, as it is, of course, impossible to operate switches or cross-overs in this form.

I believe high speeds were reached upon this railway at times, and on the opening day passengers were carried.

I think, however, at the present time that if a little more time and money were utilised in improving our steam-operated railway systems, the only reliable means of transport, that it would be more to the point.

G. GEO. WOODCOCK.

Tottenham, May 14th.

SIR,—Mr. Dendy Marshall may know that in the "History of the Hamlet of Penge," Mr. Sidney Hodgson, referring to the Forest Hill and Croydon Railway, says: "In 1846 an experiment was tried with the atmospheric pressure system, patented by J. D'A. Samuda, the engineer, between Forest Hill and Croydon. Air was pumped through cast iron tubes, 15in. in diameter, supplied from three pumping stations, that at Forest Hill still forming part of the present station. The greatest speed attained by the trains was said to have been 1 mile in 62 seconds. The changes of weather so affected the valves that the scheme was a failure, and it was abandoned after two years."

In the same book there is an engraving of an atmospheric railway, with the original captions: "View of the pneumatic railway in operation with trains on a double line passing a station," and "Sectional view of the railway cylinder showing the internal arrangement." No indication is given of the source of the illustration, but Mr. Hodgson says that it is of the system "patented by Henry Pinkus, 1834." He adds: "No suitable picture of Samuda's patent is available, but the general principle was the same."

HAROLD E. WAITE.

West Wickham, Kent, May 17th.

THE PRODUCTION OF ENGINEERS.

SIR,—I have been much interested in the leading article in your issue of May 6th, 1932, on "The Production of Engineers," but unfortunately the figures on which the arguments and conclusions are based are incorrect. It is stated that the engineers form by far the greater proportion of science students in Glasgow University and the number of science students is given as 860. Although there is an Engineering Faculty, it has been found convenient for purposes of statistics to bracket it with the Faculty of Science and the figure of 860 is correct as the total of both.

There were in the Engineering Departments in session 1930–31, to which apparently the article refers, 190 students taking their second, third, and fourth-year courses in the University. In addition, there were 37 students taking engineering courses for other degrees than the B.Sc. Engineering. First-year students do not attend classes in the Department of Engineering, but those who intended to follow engineering courses numbered about 60. In addition, there were a number of students taking engineering degree courses at the Royal Technical College, which is affiliated to the University. I have no statistics regarding the number, but it is roughly about a quarter of the number taking courses at the University.

During session 1930–31, 69 students graduated B.Sc. in Engineering (honours, first and second, and ordinary) and 2 higher degrees were awarded. This year about the same number of degrees will be granted, and it is interesting to note that of those who graduated in April of this year very few have failed so far to find employment.

The numbers in the Department of Engineering here reached a maximum in session 1921–22, and a graph shows that the greater numbers after the war were just sufficient to fill up the gap caused by the war, during which the departments here were shut down. The numbers have fallen and during the last few years have been a little more than the maximum pre-war. Under these circumstances the control of output has not come under consideration. I have no figures relating to the Engineering Departments in other Universities and Institutions, but so far as my information goes the total number of engineering students in training at the colleges in this country falls very far short relatively to the numbers in similar training on the Continent and in America.

There is one aspect which is of importance. A large and increasing proportion of students who have graduated in engineering here have subsequently found satisfactory employment in industry generally. It seems that the training, practical and theoretical, undergone by an engineering student is eminently suitable for students who become subsequently employed in industries where a considerable part of the work is dependent on machinery of all kinds.

J. D. CORMACK.

Glasgow, May 13th.

The International Association for Testing Materials.*

THE International Association for Testing Materials originated about 1885, and such well-known names in connection with the testing of materials as Bauschinger and Tetjmayer are associated with its foundation and its early work. In its later development it received widespread support, and its congresses were attended by many of the leading engineers and metallurgists of the time, among whom our own veteran, Professor W. C. Unwin, the late Professor H. M. Howe, of America, and the late Professor Martens, of Germany, may be mentioned. The Association grew in numbers and importance. My own connection with it dates back to the Congress of Copenhagen in 1909, and became more active at the Congress of New York in 1912. At the latter Congress this country was represented by a delegation of twelve, including Professor Unwin, Sir Archibald, Denny, the late Leslie Robertson, the late Bertram Blount and others, including myself. At the Congress of New York, however, we found ourselves faced with somewhat serious difficulties. At that time the International Association, in addition to discussing many subjects of purely technical and scientific interest, also endeavoured to deal with the difficult and thorny question of international standard specifications. This attempt, unfortunately, led to serious trouble, and might, if the Association had continued its work under the old conditions, have led to its ultimate disruption. As soon as international standard specifications are touched, the questions to be discussed cease to be entirely technical or scientific, and the industrial and business interests of various countries become involved. Now, I do not, personally, consider that it is either impossible or undesirable, to arrive at international standard specifications, at all events, for certain materials; but the experience gained in 1912 and even before that time, has firmly convinced me and several of my colleagues who were connected with the Association at that time that it is a highly dangerous and undesirable thing to deal with matters of this kind at international congresses, such as those of the International Association for Testing Materials. Membership of such congresses is necessarily open to a very wide range of those interested in materials of engineering, and geographical conditions generally result in a preponderant membership of those resident in the country where any such congress takes place. Further, where commercial interests of any considerable magnitude are involved, a country strongly concerned may easily take steps to secure the presence of a large number of its own nationals or their supporters. Even if such factors could be eliminated it remains true that an international congress, constituted in the somewhat haphazard fashion which is almost unavoidable in a gathering of that kind, is not the right body to come to decisions in regard to international standard specifications, or, indeed, in regard to any other matter. The fact is that decisions of such a congress, if they are taken at all, can only be taken by a majority vote, and unless the persons voting are definitely selected as representing the various interests concerned, a numerical vote can and should have little weight. For these reasons I have used such influence as I possess in the reorganisation of the International Association for Testing Materials which has taken place since the war, to eliminate not only all questions of international standard specifications from the scope of its work, but also to avoid the taking of resolutions or decisions on technical matters in a congress of miscellaneous composition.

Whether or not the dissensions arising from discussions of international specifications would have resulted in the disruption of the Association, soon after 1912, can never be known, since the intervention of the war brought the activities of the International Association to a complete standstill. In fact, it may be said to have ceased to exist after 1914. No efforts were made to revive it until in 1927 a number of those interested in the testing of materials, both in Holland and Switzerland, combined to organise an international congress on the subject, which was held in Amsterdam in September of that year.

The Congress which took place on that occasion was highly successful, and a large number of valuable papers were presented and interesting discussions took place. This Congress, however, had been held as the result of the organising labours of two groups of individuals, among whom Mr. Van der Wallen and Mr. Tjaden, of Holland, and Professor Ros, of Zürich, deserve special mention for the time, trouble, and energy which they devoted to the task. At Amsterdam there was a small British representation, and Sir Henry Fowler and I were invited to attend a conference of delegates, since circumstances had not made it possible to send officially appointed delegates from this country. None the less, we felt obliged to press upon the meeting at Amsterdam certain views which had been strongly expressed at a meeting held in London during the summer, at the invitation of the British Engineering Standards Association. Most of the delegates at Amsterdam desired simply to revive the old International Association for Testing Materials. This step I felt obliged to oppose on the grounds that the old organisation was much too elaborate and cumbersome, and that to carry it on under conditions then existing—which were not yet so difficult as they are to-day—would involve an expenditure of more time and money than could be spared for the purpose; further, the dangers which had arisen from the fact that the Association had attempted to deal with international specifications led me to urge strongly that all questions of specifications should be excluded from the scope of the work of the new Association. My view found support from the delegates of a number of other countries, and ultimately a very simple constitution was drawn up and accepted for the "New International Association for Testing Materials." The word "new" was intentionally added to the title in order to mark the fact that the organisation and objects of the Association in its revived form differed appreciably from those of its predecessor. At the present time, five years later, the Association has held another Congress for which considerable success may again be claimed. The retention of the word "new" in its title now seems unnecessary and undesirable, and at the last meeting of the Permanent Committee of the Association, held in Vienna in March, it was unanimously agreed to drop the word from the title. The Association thus resumes its old name, but does not return either to its old organisation or to its old policy.

In broad outline, the organisation of the International Association for Testing Materials as it exists to-day is based upon the fact that in the majority of countries which adhere to the Association, there are strong national societies for testing materials. Accordingly, membership of these national societies for testing materials constitutes the only qualification for membership of the International Association, but in view of the fact that there are some countries, including our own, in which no national societies exist, membership of any recognised scientific or technical society or institution is also accepted as a satisfactory qualification. The International Association is governed by a Permanent Committee, consisting of one delegate from each participating country, of a President, Vice-presidents and a General Secretary. The delegates are appointed usually by the national societies for testing materials. In our own country, where no such society exists, a British Committee, consisting, in the first place, of representatives of a number of societies and institutions interested in the testing of materials, has been formed, and, now, the Committee is being strengthened by the addition of a certain number of elected members representative of the British membership of the International Association. A large amount of work remains, however, to be done in order to secure the future of the International Association, and to make it possible for that body to carry out the important aims which lie before it. In this country, in particular, it is important to secure a large body of membership. It is important not only because of the financial support which is urgently required, but because it is only a large and active membership in this country which could justify the prominent part which your representatives have played in shaping the organisation of the international body.

The principal activity of the International Association is to hold periodic congresses at which reports may be presented and discussed dealing with the most important questions related to the testing of materials. This definition, however, is to be interpreted in the widest possible sense. On the other hand, the wide field thus opened by the work of the Association necessitates a considerable measure of selection when the subjects to be discussed at a given Congress have to be considered.

I need not detain you with any detailed account of the proceedings of the Congress at Zürich. Fortunately, the British representation on that occasion was markedly better than at Amsterdam, and although it was not as numerous as might have been wished in the interests of this country, those members who were present took an active part in the work of the Congress, and made it clear to the world that British technology is well in the forefront of technical advances in relation to the study and testing of materials. This is a matter of considerable importance, far beyond its effect upon the International Association itself. I have no doubt, as a result of contact with technical and industrial quarters on the Continent and in this country, that failure to be represented and to take an adequate part in the work of such a Congress is a serious disadvantage to any country.

I have heard it said in all seriousness that representation, adequate both in quality and quantity, at these International Congresses is of far greater industrial importance than, for example, adequate representation at an International Exhibition. For it must be remembered that reports and contributions made at an international gathering such as the Congresses of this Association, not only reach a very wide circle, including many of the leading technologists of the world, but are also subjected to close scrutiny, discussion, and criticism, and if our workers can hold their own under those conditions, they acquire a reputation which is reflected upon the industrial products of this country. I am happy to say that the importance, both from the scientific and technical points of view, and from the industrial point of view, of the International Association has been recognised by His Majesty's Government in this country. For the Congress at Zürich they appointed Sir Henry Fowler and myself as official delegates, and we were able to express to the first general meeting of the Congress the friendly interest of our Government in the work of the Association.

I am inclined to attach the greatest importance to the influence of individual leaders of thought in different countries, whose work and ideas impress themselves upon those brought into personal contact with them. The result is that in some cases very different views are prevalent in one country as compared with another. It is of the utmost benefit to all concerned that these differing views should be brought into contact by personal discussion. It frequently happens that views which are almost disregarded when they are read in print become striking and impressive when personally presented and illustrated, and it has been my experience in a number of such discussions to find that where wide divergences of opinion appear to exist at the outset, these become smoothed away and mutual understanding, if not complete mutual agreement, is ultimately reached. In other cases, on the contrary, views which were regarded as firmly established in one country were found to be in need of further investigation in the light of divergent opinions brought forward by others.

Personally, therefore, I would regard as the principal and most important work of the International Association for Testing Materials the promotion of discussion and interchange of ideas and the provision of occasions for personal contact between the workers in different countries, since these things do so much to stimulate progress and mutual understanding. There are, however, concrete results which can be and have been achieved. While it is, I am glad to say, now fully recognised that the International Association for Testing Materials shall not deal with international standardisation of specifications, it is also recognised that it is its function to deal with the problems of standardising methods of testing. This is, it will be seen on consideration, a problem clearly distinct from that of specifications. It is purely a technical problem, and deals with factors which are identical all over the world. Furthermore, international standardisation of methods of testing carries with it important advantages, whereas I have yet to hear of any disadvantages or dangers which could be associated with it.

A number of international commissions have been appointed for the purpose of carrying on international discussion and collaboration on a few selected subjects during the period which elapses between one Congress and the next. In order to secure for each nation the possibility of expressing its views before such a commission arrives at any conclusion, it has been decided that each country shall have the right to nominate one member of each commission. The somewhat large body thus created could hardly be expected to carry out such work, and the President of each commission is therefore empowered to appoint a small working committee with not less than three or more than five members, who will carry on the work. The fundamental work of the whole commission, however, is to consider and, if necessary, to revise or amend any recommendations which the working committee may make, so that representatives of every nation will have an opportunity of considering and expressing their own opinion on any suggestions which the working committee may make. Only when this has been done will any such recommendations come before the Permanent Committee of the International Association, which will then have to decide whether the recommendations are suitable for publication as recommendations of a Commission of the International Association. With these safeguards it is hoped that nothing will be put forward as an international recommendation until it has received the consideration and, it is hoped, the unanimous approval of all those interested.

In conclusion, I would appeal to all those interested in or concerned with the testing or study of materials to give their support to the International Association. I have already mentioned the importance which attaches to adequate participation in the work of the Association at these Congresses. This also applies to our activities in regard to the Permanent Committee and the various committees which have been appointed. If we desire to maintain the weight and influence which we hold at present on these bodies, it is essential that we should have in Great Britain a strong body of members, both corporate and individual. This is very important, both from the scientific and technical points of view, and from the industrial point of view also. As I have already pointed out, financial support which is derived from an extensive membership is highly important, both to the British Committee and to the International Association itself. The other kind of support which is derived from a keen and active interest in the work of the Association, which can only be demonstrated by the existence of a large membership, is equally valuable and necessary.

* Address by Dr. W. Rosenhain, F.R.S., President, May 10th.

THE "Essex Queen" left the Tower Pier at 2.15 p.m. on Wednesday, May 18th, for the first Port of London cruise to the Royal Docks.

Cylinder Liner Wear.*

By Eng. Rear-Admiral J. HOPE HARRISON (Retd.).

In this paper an attempt will be made to collect information concerning liner wear and to examine some theories that have been propounded to explain the cause. An endeavour will be made to indicate the lines along which research should proceed in order that the cause may be ascertained and the best means of preventing it discovered.

Actual Records of Wear.—Reports of actual wear have been examined from many sources. Average measurements of the maximum wear in over 200 engines have been collected, including different types of engines. If the cases of exceptional wear are eliminated the results are as follows :—

With two-stroke engines having a cylinder diameter varying between 15in. and 20in. and piston speeds from 600ft. to 810ft. per minute, the average maximum wear in thousandths of an inch per 1000 hours run is :

Parallel to crank shaft	2·04
Across crank shaft	2·55

With four-stroke engines, cylinder diameters 12in. to 21·5in. and piston speeds from 600ft. to 1100ft. per minute :

Parallel to crank shaft	1·44
Across crank shaft	1·56

In the above the total hours run vary from 1740 to 60,000. Included are records of liners that have been in use for 1000 hours with only 0·4 of one-thousand wear. Odd cases are reported of outside measurements which record 190 thousandths in 3000 hours—steel liner—and 166 thousandths in 20,000 hours—cast iron. Liners have also been reported having 250 thousandths wear. When very exceptional wear has been found in many cases piston rings have been discovered broken on opening up. Reports state that cylinder wear in small high-speed oil engines is considerably greater than in petrol engines. One estimate is that the life of a cylinder of an oil engine is 60,000 miles, against 80,000 in a petrol engine. An average—omitting exceptional cases—shows when worked out in engine-hours run, but at widely varying speeds and with much stopping and starting, 0·0025in. per 1000 hours run. No reports are included of supercharged engines for the reason that engines of this type have not been in service long enough to enable reliable records to be made. It should be stated that the evidence available appears to show that there is no reason to anticipate that excessive wear will take place in these engines in spite of the increased M.E.P. In the last report of the American Society of Mechanical Engineers, the average wear in thousandths of an inch per 1000 hours run was 2·86. These engines are almost exclusively designed for generating or industrial purposes, and the report covers eighty-one plants with 253 engines developing 146,865 (rated) B.H.P. The author has considered it advisable to give details of what may be described as a very well-operated engine. He is indebted to Mr. E. W. Johnston, to whom the gratitude of the Association is due, for the particulars shown in Figs. 1, 2 and 3, and Table I. These records have been taken over a period of twelve years from a four-stroke engine having a piston speed of 608·5ft. per minute, bore 12in., stroke 18½in.; average hours run per annum 2900·8. Recovered oil was used ; 10 per cent. of the total lubricating oil passed through the engine per week was new oil. The maximum piston clearance originally allowed in the liner was 0·020in. Brinell hardness of liner 205, rings 205. The top ring is 3⅛in. from the top of the piston, and the highest part of the liner reached by this ring is well below the top of the jacket space. The jacket space is so designed that a gas "lock" in the top is not possible. Oil is introduced for lubricating the liner at six points opposite the top ring when the crank is on its bottom centre. A separate plunger is used and sixty drops of oil per minute per liner are injected, this being twenty less than recommended by the makers. Oil is also introduced 1½in. below these six, at one hole having a bore of ⅛in. for lubricating the gudgeon pin with seventy drops of oil per minute. Oil is delivered during compression and firing strokes, and delivery commences 20 deg. before compression stroke begins. In Fig. 3, showing wear over twelve years, the letters A, B, C, D signify periods when different lubricating oils were used. Attention is drawn to the wear immediately after the liners were withdrawn and cleaned. Figs. 1 and 2 show the variation in wear across and parallel to the shaft. Cooling water has been kept circulating for twenty minutes after the engine has been stopped. Special attention has been paid, when running this engine, to water has been used for cooling purposes, very slight scale deposit has been found. Out-of-phase diagrams have been taken and examined periodically.

Reasons for renewing liners may be summed up as : (1) Increased consumption of fuel and lubricating oil ;

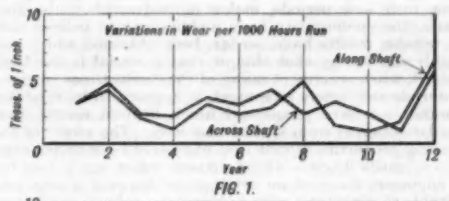


FIG. 1.

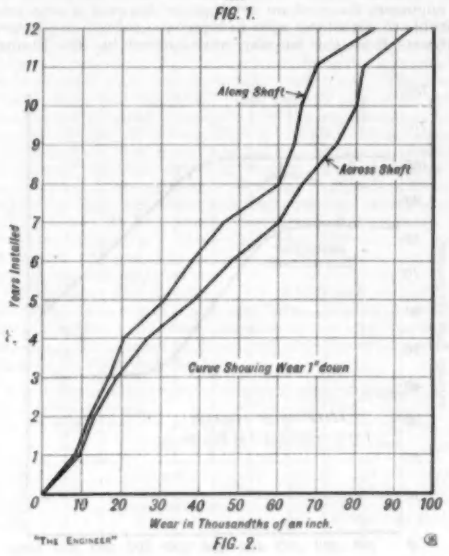


FIG. 2.

(2) reduction of maximum power obtainable ; (3) noisy running ; (4) liability to piston seizure.

Lubrication.—Are we quite satisfied that we are lubricating the liner correctly and are we using the most suitable lubricant ? Experiments have shown that oil will flow only a very short distance round the liner from the point at which it is introduced, but we still see large cylinders having as few as two or three points at which oil is injected. A large number of feeds does not mean a larger consumption ; in fact, even distribution should result in reduced consumption. There appears to be no doubt that it should be supplied not direct on to the piston ring, but along a line as nearly as possible tangential to the liner circumference. The question of whether it is possible to obtain an oil that will lubricate the combustion end of a liner, i.e., the part where wear occurs, on account of the temperature prevailing near this region has not been definitely settled. The function of the oil has been stated to be of a twofold nature. It must maintain a sufficient film on the liner walls and seal the piston rings against an escape of gas. With temperatures of 3000 deg. Fah. and pressures of 500 lb. per square inch the demands made on the oil are severe.

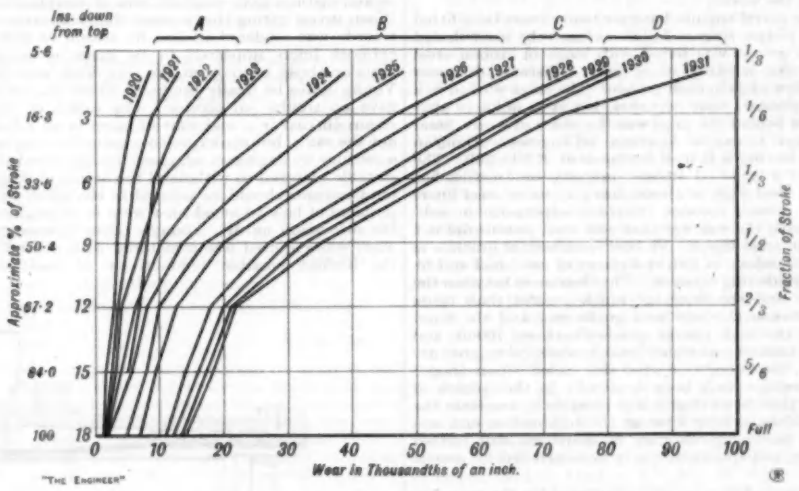


FIG. 3—DIAGRAM SHOWING LINER WEAR

The best position of the liner at which to introduce oil is still a matter of debate. It is the custom to introduce the lubricant on to the surface of the liner at a cool part in the hope that a film of oil will be carried by the piston rings to the part where it is most required. It is difficult to imagine that even a viscous oil—and no oil is very viscous at the temperatures prevailing—will prevent gases escaping at high temperatures and pressures. It is not customary to employ a different oil for bearings and for liners, and a point that is often considered important when choosing an oil is its suitability for recovery treatment. If lubricating oil is used, it is desirable to inject it on to the piston rings and not on the piston. To introduce oil through the liner on to the outer surface of the piston rings is not easy, and to introduce it where maximum wear is found is still more difficult. Assuming that a satisfactory lubricant, properly supplied, will reduce wear, we must remember the temperature prevailing where the lubricant is most required.

The temperature of the surface of liner walls has never been definitely determined, but if the temperature may rise at times above 700 deg. Fah. this is above the flash point of any known petroleum lubricating oil. Maximum temperatures after firing may be taken as round 3000 deg. Fah., abs., varying up and down considerably. Mean cylinder temperatures may be taken as 1400 deg. Fah., abs. The inner surface of the liner assuming normal running may range from 150 deg. to 300 deg. Fah. above the temperature of the cooling water, which, it may be assumed, is kept below 120 deg. Fah. Given an engine slightly out of adjustment and a high cooling water temperature, 500 deg. Fah. may be greatly exceeded. Maximum temperatures occur at from 5 to 20 per cent. of the stroke from D.C.

As far as we know at present, only running tests can determine the value of the lubricant for a particular engine.

It may be asked, can a specification be drawn up that will ensure that an oil is suitable for a particular engine in all respects ? Many experts consider it cannot. But we can by trial and error discover an oil that will give satisfactory service and endeavour to obtain a constant supply of a similar oil.

Piston Rings.—One of the most popular explanations of liner wear is that it is caused by excessive pressure exerted by the piston rings on the liner due to the high air and gas pressures behind the rings. In 1924 experiments were carried out at the N.P.L. to ascertain the influence of pressure on frictional resistance. Reports of investigation in Germany and America have been published, and in a paper before the Institution of Naval Architects in 1928 experiments carried out at the Admiralty Laboratory were described. These experiments showed how pressure falls as gases pass the piston rings, but failed to prove that gases forced the ring unduly on to the liner. It was established that two or three rings were sufficient to prevent a "blow-past," but it was stated that an undue reduction of piston ring surface tends to prevent the escape of heat to the water jackets, and piston seizures may be expected if the number of rings is unduly reduced. Mr. Sulzer, in his paper before the Institution of Naval Architects, 1926, stated the top ring is cooled when passing the hottest portion of the liner.

Users have stated that liners have been renewed on account of "piston slap." Assuming that the clearance between piston and liner was originally 0·060 at the top and "pistons don't wear," it appears to the writer to be odd that a wear of 0·080 of the liner—a figure that has been given as the maximum that should be allowed before renewal—for an inch or two down the liner should cause excessive "piston slap."

Has sufficient attention been paid to the accurate checking of piston clearances ? Pistons cannot be measured by using a pair of railway callipers. Early users had such a dread of piston seizures that they took any and every precaution to prevent them. Quite recently a new cast iron piston of medium size when accurately measured was found to be over 0·100in. smaller at the top than the normal bore of the liner. Users should insist on having accurate dimensions of pistons and liners before engines are handed over to them. We may be allowing too much clearance, but, on the other hand, big clearances may be necessary with the materials in use on account of distortion. Years ago seizures of aluminium pistons were so frequent that considerably larger clearances were allowed than with cast

TABLE I.

Liner installed 1919 ; liner replaced 1931 ; working life 34,810 hours ; bore 12in.; stroke 18½in.; average—thousandths of 1in. wear per 1000 hours—shaft 2·4, across 2·7 ; piston speed 608·5ft. per minute.

			Shaft.			Across.			Remarks.
Age.	Year.	Hours run.	Wear 1in. down.	Thous.	Thous. per 1000 hours.	Wear 1in. down.	Thous.	Thous. per 1000 hours.	
1	1920	2783	0·0085	8½	3·06	0·0085	8½	3·06	
2	1921	2800	0·012	3½	4·28	0·013	4½	4·64	
3	1922	2827	0·017	5	1·77	0·019	6	2·12	
4	1923	3795	0·0205	3½	0·92	0·0265	7½	1·98	
5	1924	3471	0·031	10½	3·03	0·039	12½	3·6	
6	1925	3132	0·038	7	2·24	0·048	9	2·88	Withdrawn and cased
7	1926	2948	0·046	8	2·71	0·06	12	4·07	
8	1927	2906	0·06	14	4·83	0·066	6	2·07	
9	1928	2855	0·064	4	1·4	0·075	9	3·16	Withdrawn and cased
10	1929	2454	0·066	2	0·81	0·08	5	2·04	
11	1930	2387	0·07	4	1·67	0·082	2	0·83	Withdrawn and cased
12	1931	2452	0·085	15	6·13	0·095	13	5·31	See below

At the end of 1930 heavy blow-past present ; double-seal rings fitted to piston grooves 2 and 3 ; no blow-past during period 1930–1931 ; liner replaced owing to noise ; no stuck piston rings found during liner life ; average hours run per annum 2900·8.

the exhaust temperatures, and steps have been taken to make any necessary adjustments whenever the normal temperature has been exceeded. Although hard untreated

* Abstract of paper read before the Diesel Engine Users Association, April 28th, 1932.

iron pistons. To-day properly treated aluminium pistons require no greater clearances in many cases than cast iron. Mr. Charles Day has very kindly given me some standard measurements of clearances allowed on engines developing 55 B.H.P. per cylinder at 300 r.p.m., cylinder liner bore being nominally 12in., reproduced in Fig. 4. A very large number of engines now in use under the supervision of our members that have been manufactured by Mr. Day's firm and have given excellent service in all respects make these

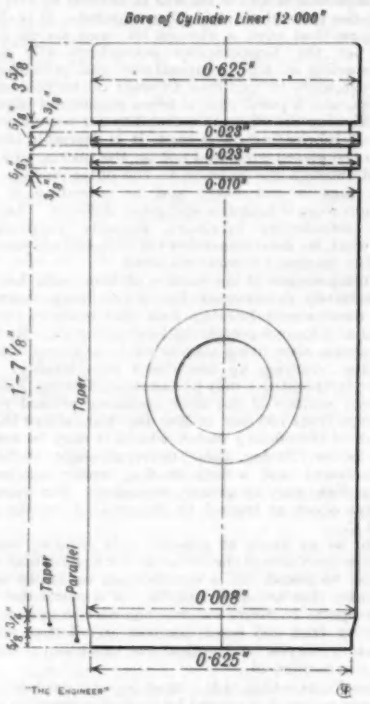


FIG. 4—PISTON CLEARANCES

of considerable value as the result of years of experience of one of the most successful heavy oil engine manufacturers in the world.

American petrol engines have for many years been fitted with steel piston rings. In an extensively used design each piston groove was fitted with rings of ribbon steel ground at the working edges only. Pistons, diameter 10in., had five rings in each groove. The rings worked in a cast iron cylinder, wear occurred, but it is unlikely that gas pressure behind the rings was the cause of wear. Steel rings are used to-day in American oil engines working in steel liners having a Brinell hardness of 275 to 300. The president of a large oil engine company in America has stated that steel rings in aluminium pistons on steel liners are now a proven success. German experience in submarines during the war was that cast steel pistons did not work well in steel liners. Vickers' commercial practice is to construct pistons of two end pieces of cast steel and fit a cast iron guide ring between. The clearances between the steel heads and the liner are much greater than those allowed between the cast iron guide ring and the liner. Even with the high piston speeds—between 1000ft. and 2000ft. per minute—at which some modern oil engines are run to-day, few reports of what was called "barrelling" in steam practice have been received. In the opinion of the writer, this shows that if it is possible to ascertain the cause of excessive liner wear at the combustion end and remove it, piston speeds may be increased still further with safety, and speeds will only be controlled by inertia stresses.

Combustion.—The type of engine used by the majority of our members, as is well known, can be adjusted to consume widely varying brands of fuel and, unlike the small high-speed engine, give good service whether using palm, coconut, linseed, tar, or any one of the dozens of petroleum base oils. For this reason, and also because in the search for cheap fuel, members have used oils having widely varying characteristics, the precise effect of fuel on liner wear has been difficult to obtain. There is one point, however, which the author is convinced is important, which is that, when changing over to an oil having a different spontaneous ignition temperature than that previously used, the correct compression pressure should be maintained. It cannot be emphasised too strongly that if combustion conditions are not reasonably good, liner wear may be excessive.

Exhaust gas at high temperature and velocity has a very erosive effect on metal surfaces. Messrs. J. Le Mesurier and R. Stansfield, in a paper read before the North-East Coast Institution of Engineers and Shipbuilders on February 26th, 1932, gave a brief outline of the essentials underlying the operation of all types of satisfactory heavy oil engines. Fuel depends for its suitability on factors other than specific gravity and volatility and the data usually included in a specification, and there are many misconceptions prevalent regarding the necessary qualities of a good fuel. Under the heading "Effect of Fuel Type on Metal Temperature," the authors remark:—"Evidence has recently been obtained which may have a direct bearing on why pistons and cylinders' heads crack with certain fuels, but not with others. The results of experiments show that the mean temperature of less well-cooled parts of engines may differ considerably if different fuels are used."

Materials.—Some of the materials of which liners have been made are:—Straight run cast iron; cast iron to which a percentage of nickel, aluminium, vanadium, molybdenum, titanium, &c., has been added; centrifugally cast iron; centrifugally cast iron alloyed in a hardened state; Perlit iron; carbon steel; steel alloyed with chromium, nickel, molybdenum, titanium, &c.; nitraded steel; steel or cast iron on which metals have been electrically deposited. If the solution of the problem of how to avoid liner wear is to be solved by metallurgists, we may have to wait quite a while. Particulars of a few of the multitude of materials that have been tried have been collected, but although the difficulty experienced in obtaining complete data, over long periods, makes it inadvisable to be dogmatic, the evidence we have inclines one to believe that no reliable results have, so far, been obtained which will enable one to say that this or that material is the best. Indeed, when records of many of the—sometimes costly—materials are closely examined, it appears to be doubtful whether we have progressed much beyond results that can be obtained from a good cast iron. The study of the wearing properties of cast iron has never been undertaken on a scientific basis. About sixteen years ago a number of engineers financed an attempt to discover a cast iron suitable to withstand wear in internal combustion engines. Extracts from this inquiry were quoted by Mr. Young.

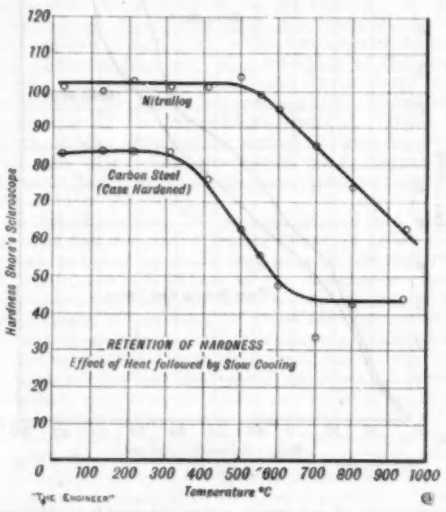


FIG. 5—HARDNESS OF NITRALLOY AND CARBON STEEL

He stated that practically 90 per cent. of Diesel engine users' records are prejudiced because the cast iron used is never twice alike. In marine work using superheated steam, castings gave constant, almost inexplicable, trouble. When investigating this matter, the comparative value of records was rendered useless by reason of the fact that cylinder liners appeared to be made of anything the founder chose to give on the day they were cast. Mr. Young states he finally produced steam engine liners that gave no trouble on service. The action of superheated steam on cast iron and that of gases in an oil engine are not the same, but the experience gained during nearly half a century by engineers who have endeavoured to obtain a suitable material to withstand the action of steam at high temperatures should be utilised in the effort to solve the problem of how to avoid liner wear in oil engines. During the discussion on Mr. Young's paper it was stated that what was required was a material with a combination of the highest possible conductivity of heat, the lowest coefficient of expansion, the lowest modulus of elasticity, and the greatest mechanical strength, and one immune from any mechanical reducing action due to the gases of incomplete combustion.

The literature on this subject contains references to cast irons which have successfully resisted wear containing a high sulphur or phosphorous content. Records show that a liner containing 0·25 per cent. of sulphur gave good service. So far as the writer is aware, the practice of deliberately adding sulphur to cast iron in order to improve its wearing properties is not carried out to any considerable extent to-day, possibly not because such an iron does not wear well, but for other reasons. The influence of nickel and aluminium has been investigated, and centrifugally cast liners have been fitted having a Brinell hardness of 350 to 400, but reports of these have not included particulars of the material from which the piston rings were made. Recently cast iron containing vanadium has been used. Isolated reports state that this material halves the normal wear of ordinary cast iron. Vanadium cast iron appears to wear rapidly for the first few thousand hours and then wear decreases. Vanadium has been introduced in the form of Norwegian Bremanger iron, which contains 0·7 per cent. of vanadium and a small percentage of titanium. Perlit iron has been reported as giving good service, though irons with special graphite or phosphoide distribution have been found to give good results. Carbon steel liners have been fitted to a considerable number of high-speed engines, but the author has seen liners of this material where very excessive wear has taken place in a short time. This may have been due to faulty operation. Mr. Mellor dealt with this point, and showed how worn steel liners had been renewed by welding. Steel has a tendency to seize unless piston clearances are large. It is used in aircraft, where large clearances can be allowed. Mr. Ricardo has stated that in a small engine it is possible to employ very much harder liners than in a large one, and the rate of wear is much the same for both low and high-speed engines, even when cast iron is used, since small cast iron liners are harder than large ones. Cylinders for road transport work are not now usually constructed, when new, with liners, but the practice of pressing a steel liner into a worn cylinder—after it has been re-bored—has lately been renewed.

The Midland Motor Cylinder Company manufactures Chromidium, which is stated to contain approximately 0·15 to 0·19 per cent. phosphorus, 0·09 per cent. sulphur, and 0·25 to 0·45 per cent. chromium. This may, after treatment, have a Brinell hardness of 260. The Laystall Engineering Works manufactures an alloy steel liner. The Krupp Aktiengesselschaft, of Essen, has recently patented a steel alloy for liners containing 3·20 per cent. chromium, 5·20 per cent. tungsten, 0·1·3 per cent. vanadium, and 0·1·3 per cent. molybdenum. This alloy may contain a substantial chromium content, but no considerable nickel content. A large range of so-called heat-resisting steels have been tried, but unless experience shows that these materials reduce wear considerably, their cost will prove prohibitive.

The process of nitrading is comparatively recent. It consists in the heating of articles made of certain steel alloys containing aluminium chromium, and molybdenum, &c., in an atmosphere of ammonia, at a temperature of from 900 deg. to 1200 deg. for from two to ninety hours at various gas pressures. Nitraded steels show an average hardness of about 1000 Brinell. One automobile manufacturer has stated that by nitrading his cylinders he can reduce wear from 0·016in. to 0·0008in. per 20,000 miles. A typical alloy that is now in use for nitrading is a composition of approximately 0·3 per cent. carbon, 1 per cent. aluminium, 1 per cent. chromium, and 0·2 per cent. molybdenum, plus a very small percentage of other alloying agents. A very important characteristic of nitraded steel is its ability to hold its hardness at high temperature. Carbon steel seldom remains hard above 400 deg. Fah. Nitraded steel, however, remains hard up to nearly 1200 deg. Fah. A curve, for which I am indebted to Mr. Charles Day, showing a comparison of hardness, is given in Fig. 5. Experience with nitraded liners is limited. Some users have shown that wear has taken place, though Mr. Wans has had satisfactory results. American reports show that care must be exercised with such liners to prevent corners at holes, &c., being chipped, and to the prevention of "flaking."

The external surfaces of liners have been "Fescolised," and I am indebted to Mr. Burn, of Richardsons, Westgarth and Co., Ltd., for permission to introduce Fig. 6, which shows the part of a liner that has been so treated.

Mr. Burn is of the opinion that this process helps to keep the jacket side of the liner clean, and therefore aids heat transmission. It has been fitted in the M.V. "Franis."

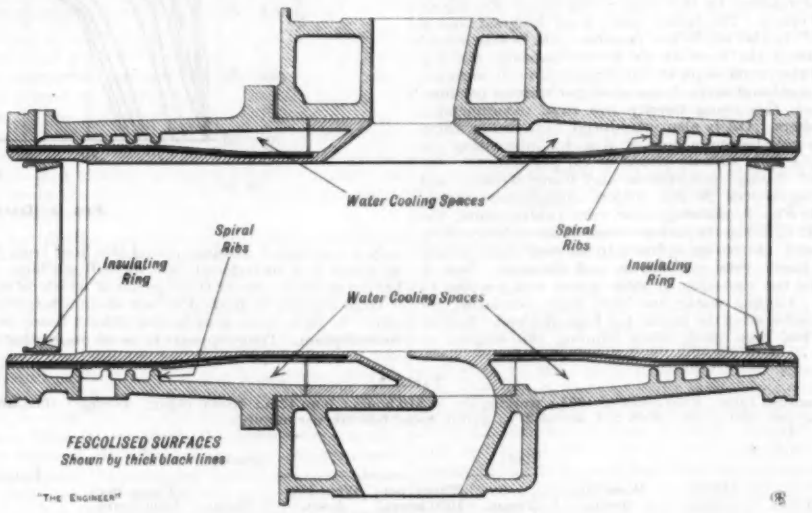


FIG. 6—"FESCOLISED" LINER

Worn liners have been repaired by depositing nickel in the worn portions, but the few cases reported where this has been done appear to show that the wearing properties of liners treated in this manner are not so good as those of ordinary cast iron. I am indebted to Mr. Wilson, a director of Fescol, Ltd., for results of trials of liners on which metals have been electrically deposited. Cylinder blocks have been "Fescolised" with hard chromium, and have given good service for the comparatively short time they have been in service—over a year.

In his last report of costs, Mr. Milton remarks: "It would be a good thing if samples of liners which have shown exceptionally good wearing properties, and others which have worn unduly rapidly, could be analysed and reported on by expert metallurgists." I would suggest that the above most excellent suggestion could be made more valuable if as many particulars as possible of operation were supplied also. Such particulars should include: Particulars of piston rings; whether liners have been removed and cleaned periodically; particulars of lubricat-

ing oil used; particulars of points at which lubricating oil is introduced and the method of forcing the oil in; periods during which engine has developed more than normal power; particulars of exhaust temperatures; and any other material facts that might throw light on the question, such as details of the cooling water used and whether it is "treated," &c.

Distortion.—Resistance to wear and the resistance to growth or distortion appear to be synonymous terms, and it has been suggested that resistance to wear and growth are proportionate to a strength factor which is probably the tensile strength. This has been refuted, and it appears to be a fact that there is no evidence that liners having a high tensile strength wear less than those of a low U.T.S. One line of advance appears to be to avoid distortion by taking every possible precaution during manufacture by heat treatment. In some tests of wear carried out by Dr.-Ing. T. Klingenstein on the wear of rubbing parts, he stated that his tests showed minimum wear when the moving and stationary test pieces were of the same Brinell hardness. He also stated that the wear is less when the moving part is harder than the fixed as compared with when the same irons are reversed. Against the above other investigators have found that minimum wear in steam engines was obtained when the rings were 10 Brinell softer than the liner. Many foundry men believe that to obtain good wear, rings and liner should be cast from the same ladle. It has been found that the time taken for the first appearance of outward signs of wear is considerably lengthened if the rubbing parts are polished instead of merely machine finished. The influence of finish has been investigated by Dr.-Ing W. Schilken. A hand-fed lapped surface was found to give an unbroken surface capable of taking an unbroken oil film, as compared with ground or reamered surfaces which showed irregularities. For many years the author had to operate other people's designs, and perhaps for that reason he is inclined to be sympathetic to users. It may be said, How are users to avoid liner wear when they have no option but to make the best of someone else's design? The answer is by attending to the following points:—(1) Maintain the original compression pressure in each cylinder, check frequently; (2) take steps to ascertain the cause immediately and correct it should the normal exhaust temperatures be exceeded; (3) keep the water side of the liner free from scale and maintain the jacket full of cooling water, periodically withdraw the liner for cleaning and easing on the outside where necessary; (4) pay particular attention to maintain correctly the point at which injection is designed by the maker to take place, by the examination of fuel valves, cams, rollers, fuel pumps, and out-of-phase diagrams; (5) using every means to avoid incomplete combustion, particularly when changing from one fuel oil to another; (6) periodical examination of the cylinder lubricating arrangements and the use of suitable lubricating oil.

A useful bibliography is given at the end of the paper.

HAMBURG CONFERENCE ON SHIP PROPULSION.

FROM Wednesday, May 18th, until Saturday, May 21st, an important conference on the hydro-mechanical problems of ship propulsion is to take place at Hamburg. It has been arranged by the Director of the Hamburg Experimental Tank and the "Friends of the Tank." The meetings will coincide with a visit to Hamburg of Dutch engineers connected with the new Experimental Tank in Holland. In the sphere of Ship Resistance contributions are to be made by Dr. Eisner, of Berlin, who will deal with the general problem; by Professor Dr. von Kármán, of Aachen-Pasadana, who will discuss various theoretical aspects; by Dr. Kempf, of Hamburg, who will deal with the resistance of flat, smooth, and rough surfaces; and by Karl E. Schönherr, of Washington, who will take for his subject temperature effects. Wave Resistance and Hull Forms will be discussed in a paper by Dr. E. Hogner, of Upsala, and by Dr. Weinblum, of Berlin; Mr. Wigley, of Teddington; and Monsieur Barrillon, of Paris. The question of Screw Propulsion will be presented by Professor Dr. Betz, of Göttingen; Dr. Weinig, of Berlin; and Dip.-Ing. F. Gutsche; whilst M. Schiller will deal with the Voith-Schneider principle of propulsion and experiments with propellers, both in water and in air.

Those attending the conference are to be entertained by the Hamburg University and the Hamburg Senate, and visits are to be made to the Hamburg Harbour, the Hamburg Tank, and to the Blohm and Voss shipyard. The results of the conference are to be summarised by Dr. Kempf and Dr.-Ing. E. Foerster.

We are glad to say that British Engineering Institutions are to be well represented at the conference. The Institution of Civil Engineers has appointed Sir John Biles as its representative; the Institution of Mechanical Engineers, Mr. Sterry B. Freeman; the Institution of Naval Architects, Mr. G. S. Baker, Sir John Biles, and Mr. Allen, of Dumbarton; while Mr. McGovern, the President of the North-East Coast Institution of Engineers and Shipbuilders, will be accompanied by Mr. H. G. Williams and Dr. Telfer; the Institute of Marine Engineers will be represented by Mr. Lumsden; and the Greenock Association of Shipbuilders and Engineers by Mr. G. W. Austin.

ADDRESSING the Marylebone Chamber of Commerce, Sir Herbert Austin said that the saturation point of taxation had been reached and the present extravagances could not be allowed to continue without the most damaging effect on industry. "I regard with a certain amount of alarm the prospect of the revenues derived from tariffs being used as an excuse for shelving the economies which should be imposed. It is vitally necessary that taxation be reduced, otherwise our chances of competing in foreign markets, even with the security which tariffs will afford us in our home market, are very remote. It is certain that unless our legislators have the courage to make economies and reduce taxation the next Budget will show a decided drop on the receipts side, because taxes are killing the very source from which they are expected to emanate."

World Steel Trade: Position and Prospects.

By E. T. GOOD.

THE British steel trade, as compared with foreign competitive trades, is both good and bad—good because the per ton value of its output and exports is the highest in the world, its quality of product being the best; bad, because we are failing, and have for many years been failing, to retain our due share of the world's business in ordinary steel. It is only a question of time till the world will consume record-breaking tonnages of steel. The depression is temporary. When revival comes, shall we be ready for it? Shall we increase our share or percentage of the world's total?

The pre-war record output for the world was 75,000,000 tons for one year. The production has reached 121,000,000 tons in a year since the war, and only financial stringencies have caused a decline from that high level. The world wants more, not less steel. Vast railway and other steel-consuming schemes planned before the war have not been carried out yet. There are single countries wanting between 30,000 and 50,000 miles of new railway. There are millions of tons of obsolete shipping waiting to be "scrapped" and replaced by modern "economy" vessels. Steel is replacing, and will more and more replace, wood, stone, and brick. Wood cannot cheapen, and it cannot be improved in quality. Steel is as cheap as before the war; it is better in quality, and is being constantly improved and given fresh applications.

Later than the middle of the nineteenth century we made half the world's iron and steel. By 1913 we had been relegated to the third position among steel-producing nations. Since then we have had this record in tonnage figures, for five countries:—

Production of Steel in Tons; Monthly Averages.

	Britain.	United States.	Germany.	France.	Belgium.
1913	638,600	2,608,400	1,445,700	384,500	202,300
1 29	803,000	4,513,700	1,332,700	792,800	339,000
1930	608,200	3,304,400	946,500	771,300	285,000
1931	431,500	2,075,000	680,300	640,700	256,100
Single Months.					
1931, March	500,100	2,993,600	800,500	710,800	243,800
1932, March	462,800	1,410,800	428,000	456,700	246,500
1931, April	397,400				
1932, April	433,300				

The extent to which we have been subjected to foreign competition in recent times, as measured by tonnage, is as follows:—

British Imports and Exports of Iron and Steel and Products, exclusive of Engineering Goods, in Tons; Monthly Averages.

	Our Imports.	Our Exports.
1907	84,000	432,600
1913	185,900	414,100
1931	237,700	165,100
Last Six Single Months.		
1931, November	379,400	195,700
December	266,900	175,300
1932, January	170,400	167,300
February	252,300	139,800
March	130,200	166,400
April	144,500	180,400

But in values we have these figures:—

Iron and Steel Imports and Exports April, 1932, Values.

Our imports	£760,752
Our exports	£2,549,732

With a new fiscal policy we are hoping to increase our share of the world's trade, especially our trade with the Dominions and Colonies, to reduce our competitive imports and keep a greater percentage of the business in the home market; but at present trade is out of normal gear. Some of our Continental competitors are exporting at prices more below actual costs than ever previously quoted. These figures show the recent price fall:—

Continental Steel Prices for Export at Antwerp, per ton.

	End of 1929.	End of 1930.	End of April, 1932.
Steel billets	91s.	67s.	55s.
Sheet bars	91s. to 93s.	70s. to 73s.	55s. 6d.
Merchant steel bars	105s. to 106s.	83s. to 88s.	60s.

The Germans are ceasing to sell much below cost, and their exports have declined by 50 per cent. in the last twelve months. How much longer the others can continue selling below cost is a matter of speculation; but French exports are one-third less in tonnage than twelve months ago. The exports of Belgium are being maintained—up to the present—at a level only slightly below the monthly average for 1931.

At the moment there is only a slight improvement in some branches of our industry, mostly in the light lines, such as tools and tool steels, high-speed steels, thin sheets, and bars of high grade, magnets and magnet steels, stainless and heat-resisting steels, and some lines of cheap cutlery now manufactured on mass production principles. Demands from shipyards, railways, and collieries are very low, and there is not the usual seasonal demand for constructional steel, apart from shapes for the national electricity scheme. The tube trade is fairly active.

THE OUTLOOK.

The demand for steel and products can hardly be expected to revive much in the very near future. It is not that the world wants little steel—or less steel than in previous years; it wants very much more—enormously more railways are required in many countries, more bridges, more vehicles, vastly more farm implements, and many more mining and forest tools. But financial stringency and political troubles are half paralysing trade. Railway steel may be the first to be in huge demand when money matters are half smoothed out. India was calculated to want another 30,000 miles of railway on the eve of the Great War. Little has been done, first because of the steel famine during the war, next because of high prices after the war, and next by the drop in the value of silver and other commodities produced in India and the East generally. India is extremely short of railways and equipment. Vast arrears stand waiting to be made good. In the Latin Republics of South America, in various parts of Africa, and in some Northern European countries, railway constructions and equipments are far below requirements. Farmers nearly the world over are short of implements—using obsolete things because, with produce prices extremely low, they have little or no money for new purchases. If and when a moderate rise comes in farm produce prices there will be heavy and widespread buying of farm implements. The Canadian market is already improving for British steel and engineering goods. In Africa and some other quarters there have been such serious failures with foreign steel and engines that British products are bound to come into more favour.

STEEL AND SHIPBUILDING.

Not many of the enormous number of ships laid up, here or abroad, will ever carry cargoes again. Their next voyages will be to the breakers' yards. Unfortunately, the price of scrap steel is very low—nearly 50 per cent. lower than it was three years ago—and many owners are disinclined to accept current prices of vessels for scrapping. If and when steel makers can offer fair prices for scrap, we shall see ship breakers extremely busy, and most of the owners will get more money than will probably be spent on new "economy" vessels. Our shipbuilders have made great technical strides recently—so many improvements in designs, hulls, boilers, engines, and auxiliary machinery—that even moderately aged ships are in many cases quite obsolete now. Many owners will have to get new, modern ships, somehow, or go to the bankruptcy court. Fifty per cent. of Germany's merchant tonnage is under ten years old. Aged ships will not be able to compete with success against the new vessels builders offer to-day. A revival in shipbuilding may come, as Mr. Batey, of Hebburn, says, like a thief in the night. Steel makers may lay their plans in confident expectation that there will be great demands for railway and ship steels in the not distant future—unless bankers and Governments fail absolutely to get the machinery of money in better order and so drive the world's trade to disaster. The failure of finance is the chief cause of our depression. The machinery of production is adequate and excellent. The wants of the world are bigger than ever. Let the controllers of currency and credit play their part rightly and quickly, and trade revival will be certain and rapid.

THE POSITION IN AMERICA.

The United States will probably be the last country of industrial importance to get out of depression. It may be that she will never get back to the level of steel production she attained in 1929–30. Capacity has been forced far above requirements. When the steel rail output touched 3,000,000 tons in one year, having doubled itself in about a decade, mills were planned and built to make 6,000,000 tons a year. The demand is not good enough for 1,000,000 tons. The situation was totally misjudged. There is such a vast network of railways that no considerable extensions are needed. There are more than enough factories, so the demand for structural steel is not likely to be great for several years to come. Steel shipbuilding has slumped by 90 per cent. since the high record of 1920 was made. There is no sign of improvement. America has far more than plenty of ships. She cannot possibly enter into the competition for exports of ships or for steel rails, or any heavy goods, because ore and coal mines are so far apart, and her works and ports or docks are so far apart, that her excessive transport charges for ore, lime, fuel, and finished steel put her right out of serious competition with Britain or Europe for heavy steel products and for ships. United States exports of iron and steel have dropped from a monthly average of 242,300 tons in 1913 to 31,600 tons in February, 1932, and this meagre tonnage is almost confined to next-door Canada, where British steel is now getting a better footing. The overseas trade of America is nearly off the map, because of enormous transport charges, resulting from enormous overland hauls.

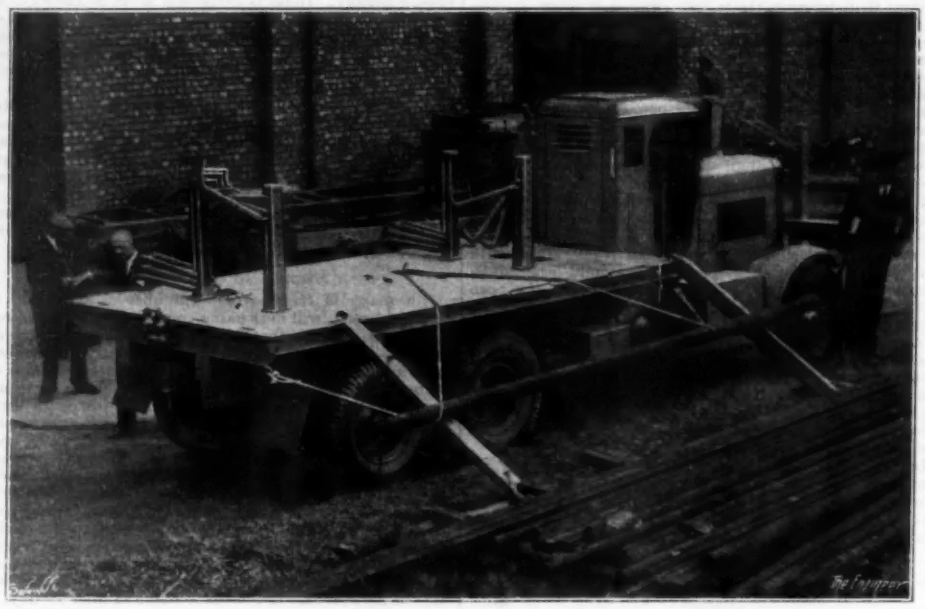
RUSSIA.

The bogey of Russian competition has been raised once more. We are again told of the great ore and fuel resources of Russia, of the cheap labour of that country, and of the plans to develop a huge export trade in steel. The facts are that ore, coal, works, and ports are too far apart to allow Russia to make and export steel at anything near a competitive price. It costs nearly 50s. per ton of pig iron to assemble the raw materials. It costs another 50s. to carry a ton of steel to port. In the next place, the railway facilities are so meagre that no great export trade could be done if the costs were right, nor are the dock facilities good enough for an extensive business. Russia cannot make nearly enough steel for herself, and she is making great efforts to import from Germany sufficient to keep her engineering works going. Russian export competition in steel will prove—as Russian competition in coal has proved—impossible.

IN determining the magnitude and distribution of iron and stray losses in various parts of the new 100,000 kVA, 13·8 kV, 1800 r.p.m. turbo-generator, now under construction for the Public Service Electric and Gas Company, the engineers of the American Westinghouse Company have largely eliminated empirical formulas and substituted special tests. The generator is brought up to constant temperature under the load condition to be studied, including zero power factor, no-load normal voltage, and sustained short circuit. The field is then suddenly switched off and the temperatures of about 30 thermocouples imbedded in the parts to be studied are read at one-minute intervals for about forty minutes. Knowing the specific heat of the material being studied and its rate of cooling at the instant the field is thrown off, the loss by that particular part can be determined.

LORRY FOR HANDLING PIPES AND BARS

LEYLAND MOTORS, LTD., LEYLAND, ENGINEERS



A Special Lorry for Handling Pipes and Bar Material.

In the accompanying illustration a view is reproduced of one of a series of special lorries, which have been constructed for the pipe-laying service of the Burmah Oil Company, Ltd., by Leyland Motors, Ltd., of Leyland, Lancashire, in collaboration with Bromilow and Edwards, Ltd., of Bolton. The vehicles are designed to carry loads up to 7 tons, of pipes of any diameter up to 4ft. with a maximum length of 40ft. They load, transport and unload without the aid of a crane, and are built to operate over rough ground. The basis of the design chosen is the Leyland Terrier chassis, which is designed to conform with War Office specifications, and is, therefore, particularly suited for the task to be undertaken. It is a six-wheeled vehicle, with specially strong brakes and chassis parts, which are designed either to negotiate uneven surfaces or to operate satisfactorily on loose, sandy ground. The engine is a six-cylinder unit with a bore of 4¼in. and a 5in. stroke, and it has a 43·4 H.P. R.A.C. rating.

Owing to the length of the pipes which have to be carried, it is necessary for them to be loaded along each side of the cab, so that they can extend over the full length of the machine. Further, in order to provide accommodation for as many as possible, the cab width has had to be cut down to the minimum which will allow for the reasonable comfort of one man. The steering and all controls are conveniently centralised. The pipes, when in position, are, as indicated by the photograph, carried on three bolsters arranged on each side of the vehicle. On each set of bolsters there is a series of pipe clamps which can be placed over each layer of pipes. The clamps, in addition to forming a method of securing the pipes without the necessity for any lashings, form beds for each succeeding tier. They run in adjustable sockets, which are designed to accommodate varying diameters of pipes and to take any number of lengths.

The lifting and lowering operations are carried out by means of hawsers worked from niggerheads or revolving bollards, which are arranged on each side of the chassis just below the level of the driver's cab. They are worked from an auxiliary drive taken from the main gear-box and have forward and reverse motions.

When loading on the offside of the vehicle the nearside niggerhead is used, a hawser being placed round it and then passed round rollers, which lead it up through holes provided in the centre of the platform, and thence over further rollers on the side of the body and around the pipe to be loaded. For test purposes, as shown in our illustration, owing to the fact that no suitable pipes were available, square and round bars of iron, each weighing approximately ½ ton and upwards, were utilised. When the hawser had been placed round the bar selected, the niggerhead was engaged by the man in the driver's cab and the bar hauled into position on the platform body up ramps placed at intervals along the side of the vehicle, each bar taking approximately half to one minute to get into position. As each tier was completed, the pipe clamps were dropped into position and the next tier begun.

When the lorry is loaded with a full load of pipes, running the full length of the vehicle, it is obvious that egress from the driver's cab in the usual manner is impossible. The back portion of the cab is, therefore, made in the form of a door, but as it might so happen that a load was being carried on the rear portion of the platform, provision is also made for the driver to be able to leave the cab through the roof.

In addition to the work of transporting pipes, the vehicles have been designed for carrying machinery which may be used in the course of pipe-laying, such as pumps, &c., and in order that they may be suitable for such work, the pipe bolsters are removable, thus leaving a clear, flat platform.

Small Power Transformers for 132 kV Circuits.

In our issue of July 10th, 1931, we mentioned that the B.T.H. Company was manufacturing potential transformers for direct connection to the 132-kV "Grid" network without intervening switchgear or fuses. Eighty-five of these transformers have now been delivered, and are being put into service. They are of the shielded surge-proof type, and are insulated to be stronger under impulse conditions than a 41in. air gap, a bushing with a dry flash-over at 50 cycles of 380 kV, and a string of insulators with a dry flashover of 455 kV.

In the design of the transformers precautions were taken to ensure that transient over-voltages and surges will be uniformly distributed throughout the winding and not concentrated on the end turns. During the course of manufacture tests were made to determine the voltage distribution throughout the windings, both with the shields in position and with them removed, and the interesting results obtained are shown by the curves, Fig. 1. The tests were made with a variety of wave forms of the applied voltage.

As these potential transformers—Fig. 2—are associated with discriminative protective gear, the ratio and phase angle when the supply voltage is only a fraction of the normal—such as half a degree—are matters of considerable importance. Special tests were therefore made on all the units, and in every case the results were well within the specified limits of Class H of B.S.S. 81. By the addition of oil ducts throughout the windings, involving only a slight increase in the height of each transformer, it has been possible to obtain an output of 75 kVA per three-phase bank, and two three-phase banks, or six transformers in all, have been installed in one of the "Grid" sub-stations to provide the entire power supply for lighting, heating, and cooking in the sub-station office building and associated dwellings and auxiliaries in the station.

These units are shielded in a similar manner to the potential transformers, and the curves given in Fig. 1 also apply to them. As the height from the ground level to the bottom of the porcelain of the high-voltage bushing is 1in. over the Home Office requirements of 8ft., it is unnecessary to provide additional plinths. The overall height when erected is 15ft. 3in., and the weight complete 8000 lb. The introduction of these small 132-kV power transformers marks an important step in electrical engineering, for not long ago it was considered impossible to tap the "Grid" lines without the use of very costly switchgear.

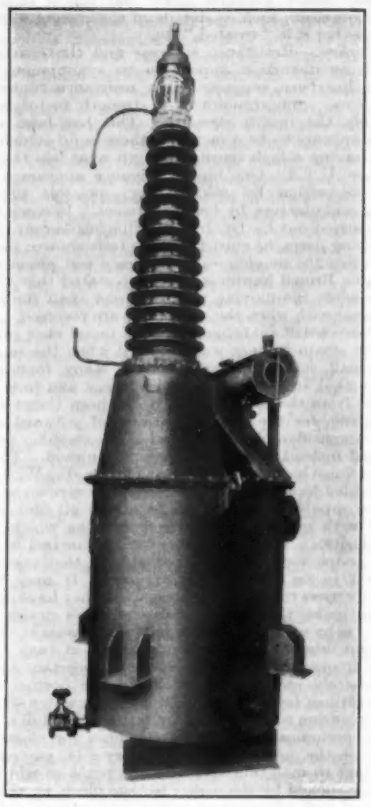


FIG. 2—132-kV POTENTIAL TRANSFORMER

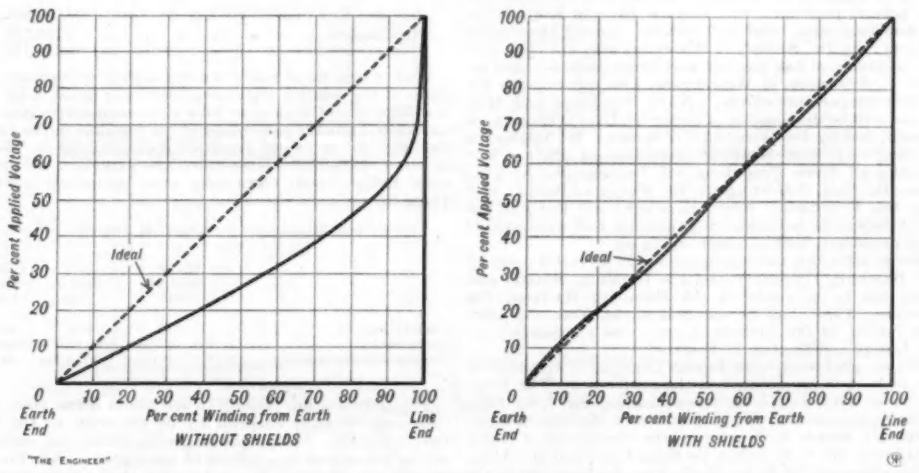


FIG. 1—INITIAL VOLTAGE DISTRIBUTION ON IMPULSE TEST ON 132-kV POTENTIAL TRANSFORMER

American Engineering News.

Made Land in Chicago.

A large part of the parks extending along the Lake Michigan water front at Chicago consists of made land, formed either by the slow, but continual, dumping of rubbish or by the rapid process of pumping in sand from hopper dredges. At present an area of about 500 acres is being added to Lincoln Park on a length of about 2 miles of shore. Seven hopper dredges are at work. They go about 25 miles south of the city to fill their holds with clean sand pumped up from the lake bottom. At the park extension they move alongside piers and connect their discharge pipes to distributing mains 36in. in diameter, which are laid along the piers and on temporary trestles over the area to be filled. From these mains, laterals of 30in. to 18in. diameter are shifted over the area, as required. Loose joints in these laterals enable the sand to be deposited at any desired point. The largest dredger has a hopper capacity of 6000 cubic yards, and can discharge this cargo in about three hours. It is a single-screw steamer, with turbo-electric drive and a sea speed of 14 to 15 miles per hour. Part of the sand forms bathing beaches. In other parts it is filled in 5ft. to 15ft. above water level and is retained by a sea wall of interlocking steel piles. These piles, 40ft. to 45ft. long, are driven in two rows about 20ft. apart, with transverse walls of similar construction at intervals of 75ft. to tie the walls together. Loose rock is filled into the compartments or cells thus formed, and is covered by massive quarry blocks laid to a level surface flush with the tops of the piles. About 7,000,000 cubic yards of sand are being placed

for the beaches and made land, the latter being landscaped and laid out with turfed areas, trees, driveways and lagoons.

A Pontoon Bridge.

The usual conception of a pontoon bridge is a series of pontoons anchored parallel with the stream and supporting a continuous deck or superstructure. But in some railway pontoon bridges on the Mississippi River, a single pontoon 300ft. to 400ft. long, extending across the current, forms the drawspan in the navigation channel, timber trestles connecting it with the shore. A new pontoon or floating drawspan placed in the bridge of the Chicago, Milwaukee and Pacific Railroad at Wabasha, is 396ft. long, 50ft. wide, and 7½ft. deep, with a draught of 3½ft. light and 5ft. with a heavy train. One end is pivoted on the downstream side to a group of piles. The upstream side of the opposite end rests against a pile pier. At this latter end is a steam winch operating a sprocket wheel engaging a chain, which is laid diagonally across the bed of the river, this chain having links of 1½in. iron, 6in. long. To provide for the great changes in water level, the track is not laid directly upon the deck of the pontoon, but the sleepers rest upon longitudinal girders seated on cross girders of heavy rolled steel joists. The ends of these joists lie between groups of vertical guide timbers, where screw jacks are placed to raise or lower the deck, the adjustments being made by blocking placed under the joists and within the guides. In the hull are five longitudinal bulkheads, built up solid with timbers 18in. wide, 10in. thick, and 20ft. to 60ft. long, fastened together by through bolts and having ring dowels or shear dowels fitted between them. Transverse trusses are worked between the bulkheads and the frames, which carry the 4 by 10in. sheathing and deck planking. All hull timbers are creosoted and were shaped and bored before being treated.

Developments in Mining.

During 1931 there was an increase in the use of belt conveyors for carrying ore in American mines. In most cases they are horizontal, but in one mine a crusher underground delivers the rock to an inclined conveyor, which extends to the surface, a vertical distance of 120ft. The results indicate a further use of this method. There was also a steady increase in the use of cable-operated scrapers to haul ore from the stope pockets to loading points, and for bringing rock from the headings of drifts and tunnels. Their use even in the smaller mines promises to be economical, while, on the other hand, still larger scrapers and more powerful haulage are likely to be introduced for handling hard, blocky ore and when large tonnage is required. In some mines, however, the economic limit in size and power has been reached, since larger scrapers would endanger the timbering. In general, the use of electric power is superseding compressed air for such work. An example is a mine in which scrapers weighing rather more than a ton and operated by 65 H.P. motors handle 500 tons each daily, with a haul of 75ft. to 150ft. For similar work handling larger tonnages motors of 150 H.P. may be practicable. Reduction of weight of mine cars, skips and cages by about 30 per cent., without loss of strength or durability, has been effected by the use of alloy metals. Gold mining and prospecting has shown increased activity, with some new mines opened, while mining methods have been improved to obtain a higher extraction of ore and to meet the requirements of deeper workings. In a new method of stoping at the Michigan copper mines, the stoping begins at the extremity of the ore and works back towards the shaft. The ore is broken on levels 33ft. apart vertically, and is moved by scrapers to raises spaced about 250ft. apart.

Ready-mixed Concrete.

Within the past few years there has been a rapidly increasing use of ready-mixed concrete, the mixing being done sometimes at a central plant and sometimes partly or entirely in mixers which form the wagons in which the material is transported to the place where the concrete is to be used. At one plant, sand and gravel are delivered to bins above the mixers by elevator belts. For wet-mix concrete, a 2-yard mixer is used, and the concrete is delivered to motor trucks. For dry-mix concrete, the batch of specified proportions is delivered to travelling mixers, or mixers mounted on motor truck frames, water being supplied in a regulated quantity from a tank above the mixer drum during transport to the point where the concrete is to be used. Cement is delivered to the works in bulk by closed dump-body motor trucks and fed to the storage bins by continuous bucket elevators. Another and larger plant uses both stone and slag for the coarse aggregate. Only dry-mix concrete is produced here, in batches from ¼ yard to 4 yards, the measured batches being delivered to mixers of the horizontal drum tilting type, mounted, with petrol engine, tank and revolving machinery, on a motor truck frame. Bulk cement is used and is delivered to the measuring hoppers by screw conveyors. However, where special brands of cement are specified, these are delivered in sacks. Many improvements in methods and equipment have been made in order to make the system satisfactory to the customer and productive of concrete of the quality or proportions specified. These improvements include exactness of proportions, time of mixing, and other details, as well as new designs of mixers, with mechanism for revolving and tilting the mixer and supplying water automatically.

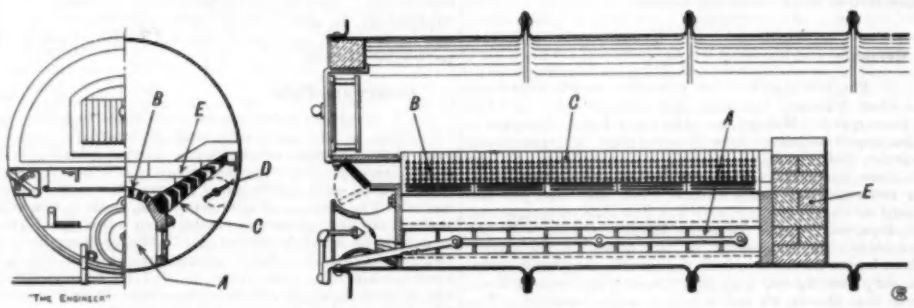
Limestone and Lime Works.

At the new Kelly Island limestone plant stone from a 60-acre quarry, 80ft. deep, is crushed to various sizes and burned in vertical and rotary kilns, producing about 600 tons of lime daily. The quarry rock is first passed to crushing rolls, and then elevated to revolving screens, which deliver it in sizes of 12in. to 5in. for the kilns, and 5in. to 2½in. for furnace flux, the material smaller than 2½in. going to a separate fine-screening plant. All the buildings are of steel, with corrugated iron sheathing, finished inside and out with aluminium paint and all operations are made practically dustless. Individual electric motors operate the various units through enclosed speed-reducing gears or V-link chains. Beneath the screen-house are eight cylindrical bins, with a total capacity of 1500 tons. They are in two rows over railway tracks and fitted with revolving gates for discharging into cars. Re-crushing is done in a 4ft. cone crusher, and the material is passed to vibrating screens, which produce various sizes up to ⅜in. The smallest sizes are used by glass works and the larger sizes for refractory purposes at steel works. For the hydrating plant, all units have individual electric motors, with enclosed reducing gears and protected roller-chain drives. The hydrate from a set of hydrators goes to three steel cylindrical bins, 30ft. in diameter and 80ft. high, each with three discharge hoppers in the bottom, fitted with rotary feeders which regulate the flow to screw conveyors. These conveyors discharge into hoppers feeding ball-mill pulverisers, the fine product from which is carried by continuous bucket elevators to bins which supply two packing machines. Each machine fills four sacks simultaneously, and these are either sent to a storage house, or loaded into railway cars. The stone which is to go to the hydrators is given a preliminary crushing in a hammer mill. Automatic control provides that in case the current consumption of all units becomes excessive, the feeder to the cone crusher is stopped and a whistle signal given for stopping delivery of stone to the crushing rolls.

A New Form of Fire-grate for Lancashire Boilers.

THE drawing which we reproduce below represents a new form of furnace, devised by C. F. Wade, and made by the Brightside Foundry and Engineering Company, of Sheffield, which is claimed to be specially applicable to Lancashire boilers using coal of such a quality that it is difficult to prevent the emission of smoke.

The furnace, it will be seen, consists of an air box or trunk A beneath the centre of the grate, into which the whole of the combustion air is introduced from the front. This air trunk has at its sides adjustable sliding shutters operated by handles, and at the top convex crown bars or grids B, admitting air to the centre of the dished fire-grate C. The main fire-grate consists of loose, transverse fire-bars, the air spaces through which are of converging nozzle shape, serving not only to provide primary air, but also secondary air above the fire for its whole length, in fine streams, from the outer rows of air spaces. The active grate area is adjusted and secondary air supply regulated by the swivelling dampers D, which partially or entirely shut off about a quarter of the total grate area, as required.



FURNACE FOR LANCASHIRE BOILERS

In lighting up or rebuilding the fire after cleaning out, the side shutters in the air trunk are closed, thus concentrating the air supply on the centre of the fire bed, and, as the fire is built up, the shutters eventually are fully opened. With a full fire, the wing dampers D are adjusted for the best conditions of combustion, either by aid of a CO_2 recorder or by visual observation of the chimney, i.e., so that no smoke is formed. Under these conditions the furnace is, the inventor says, virtually a gas producer with immediate combustion of the gases above the fuel bed. The effect of the converging nozzle-shaped air spaces is to deflect the partially burned gases from the furnace walls and to set up vigorous turbulence, thus obtaining almost ideal conditions for perfect combustion, with minimum excess air and consequent maximum furnace temperature.

By the use of the sliding shutters in the main air trunk at cleaning out times, one side of the fire is kept fully active, while the air is entirely shut off from the side being cleaned out. After both sides have been cleaned there is a large bulk of burning fuel ready to get the fire built up again, since, owing to the convexity, the centre crown bars support a heavy layer of fuel on the side not being cleaned out.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Whitsun Holidays.

THERE has been little activity in industrial circles in the Midlands and Staffordshire this week owing to the Whitsun holidays. It would appear that consumption of iron and steel is likely to be light in Midland industries for some little time ahead, though hopes are still held of improvement later on. Seasonal activity is marked in some of the light metal trades in the Midlands, and motor engineering is proceeding apace. Accessory manufacturers are well engaged. Next week should see more trade movement in all branches, while market activity is certain to be to some extent renewed.

Steel.

Steel prices alike for finished and unfinished material are unchanged. The position must, sooner or later, be tackled by the makers' Association, especially as many steelmasters are dissatisfied with the present rates. Values have been stable for a long while, periodical reviews of the positions having resulted in a reaffirmation of the existing rates for finished material. In the half products department native makers have adjusted their prices where possible to meet foreign competition, but they are still undercut and have consequent difficulty in securing sufficient business to keep plant regularly employed. There is practically no buying of either native or foreign semis, however, at the moment.

Finished Iron.

Recent price concessions in the Crown and common bar branches of the Staffordshire finished iron trade have not resulted in any marked accession of demand, and ironmasters' production is on about the same level as during the opening weeks of the quarter. Makers of marked brass are relatively better placed than producers of other grades, and they are able to maintain selling prices at £12 per ton. Wrought iron strip for the tube trade sells fairly steadily at £10 10s. per ton. Most of the heavy iron consuming industries in this area are working much below the normal, while this week little material has been made up. Stocks at the works are not large.

Pig Iron.

Midland pig iron prices are stable at £3 6s. for Derbyshire and North Staffordshire No. 3 foundry grades, and £3 2s. 6d. for Northamptonshire. Consumption is light in the heavy engineering foundries, and none too good in the light foundries. Specifications are difficult to secure, while new business relates to hand-to-mouth orders. There are no signs of a renewal of activity at the forges in this area, and sales of forge pig are negligible. Stocks of iron at the furnaces have increased as a result of holiday restricted production at the foundries, and the whole position is far from satisfactory at the moment.

Galvanised Sheets.

There is no change on the week in the galvanised sheet industry. Makers are still fighting to uphold prices, but overseas business is so badly needed to keep the mills engaged and price concessions are almost the rule for this work. Though £9 10s. is still demanded for home business and is quoted for overseas orders, £9 7s. 6d. is accepted for the latter. A few mills ask higher prices, but they do not appear to be meeting with much success. Business is dull alike on home and export account.

Toy Manufacture in Dudley.

It is announced that the American firm of Luis Marks and Co., Ltd., is shortly to begin the manufacture of mechanical toys in a factory at Dudley, thus providing the Black Country with yet another industrial line. The firm has taken over a portion of the former Bean Car Works, which have been idle for a long time, and as Messrs. Luis Marks are credited with being one of the largest manufacturers of mechanical toys in the world and with the intention of producing on a large scale at Dudley, the enterprise is widely welcomed. Success should be of ultimate advantage not only to Dudley, but to the Black Country generally.

Darlaston Screw Spikes for China.

Some interesting details have recently come to hand relative to an order for 500 tons of railway steel screw spikes for the Chinese Government, which has just been completed by Charles Richards and Sons, Ltd., Imperial Nut and Bolt Works, Darlaston. The order, which had to be completed in five weeks, was ready well within the specified time. In the operation for forging and rolling the screws, which are about 5in. long with square heads, approximately 600 tons of steel bars, 100 per cent. British, were used, and 120 tons of fuel oil were burnt in the furnaces. Over a ton of 3in. nails were used in fastening down the lids of the 5760 cases in which the screws were packed for conveyance to China. The screws were made and finished in the forging department of the Imperial Works, and found work for some seventy of the firm's 1000 workpeople.

Coal Output.

The regulated output of coal in most of the coalfields in this area has lately approximated much more closely to the official allocation than for a time after the scheme of regulation was first introduced. Late official figures show that in December quarter last, Warwickshire had an allocation of 1,230,000 tons, and the output amounted to 1,229,000 tons. In North Staffordshire and Cannock Chase output was also very near to allocation, but in South Staffordshire, as in other areas—Bristol, South Wales, and Monmouth—there was a wide difference

between the quantities allocated and the actual output. In these districts the production fell much below that permitted under the regulation scheme.

Gas Engineers.

There was a large gathering in Birmingham on Thursday last week of gas engineers attending the spring general meeting of the Midland Association of Gas Engineers and Managers, which went off with every success. During the day members were shown over the Nechells and Saltby Gasworks, where they examined the chemical laboratories and other departments, visiting also the industrial research laboratories, the meter and store shops, and the heat treatment foundry. Speaking at the luncheon, Mr. J. H. Canning, President of the Institution of Gas Engineers and Managers, referred to the future developments of the industry, which, he said, he believed lay to a great extent in the industrial field. Alderman J. N. Lloyd, Chairman of the Birmingham Gas Committee, presided at the luncheon, and he had the support of the Lord Mayor, Alderman J. B. Burman.

Birmingham Order.

The Birmingham Corporation Tramway and Omnibus Committee has recently ordered from the Cargo Fleet Iron Company, Ltd., of Middlesbrough, 940 tons of grooved steel girder tramway rails and 550 pairs of fish-plates.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Textile Machinery Exports.

EXPORTS of British-made textile machinery during April continued to be well below the value in the corresponding period of 1930, but, whilst they are slightly lower than the average also of the first three months of the present year, they represent an improvement compared with April, 1931. Shipments to Russia during the month under review were almost negligible, and the influence of the French quota system is amply reflected in the exports to that market, last month's total reaching only £13,087 in value, compared with £51,363 in April, 1931, and £90,922 in the corresponding period of 1930. Exports to British India are slightly below the level of the two previous years, but in all other respects the markets show some degree of improvement over April of last year. Last month's exports amounted to 21,592 tons, valued at £462,492, including 14,603 tons of spinning and twisting machinery of the value of £312,018, and 5295 tons of weaving machinery valued at £100,166. The total shipments in April of last year were 16,472 tons, valued at £435,428. British India continues to be the principal export outlet for British machinery of this class, the takings by that market during last month reaching a value of £156,832, or nearly 35 per cent. of the total shipments. China occupied second place, with shipments valued at £51,475, followed by South America £25,605, Japan £25,281, the Netherlands £22,674, Germany £15,347, the United States £13,219, France £13,087, Australia £8697, and Russia £5864, exports to "other European countries" reaching an aggregate value of £99,616, compared with £89,037 in the corresponding month of last year.

The Clarence Dock Power Station.

An official statement has been issued by the Town Clerk of Liverpool, Mr. Walter Moon, bearing upon rumours which have recently been circulating regarding the new power station under construction at the Clarence Dock, Liverpool. The total cost of the station when it is completed will, it is stated, be in the region of £5,800,000. The first section, which has been in operation since last July, cost about £1,800,000. The plant in this section is in full operation and is proving extremely efficient, current being generated, it is claimed, at the lowest cost of any in the country. Regarding the rumours in question, the statement of the Town Clerk says: "It is absolutely false to suggest that there is a serious fault in the building. Not only is the building perfectly safe, but also all the machinery contained in it, and the sense of responsibility of the officials is much too great for them to permit any plant to be used if there is the slightest degree of danger to anyone, either the public or the staff."

Mechanical Coal-cutters and Wage Rates.

Evidence of representatives of the Lancashire and Cheshire Coalowners' Association and of the Lancashire and Cheshire Miners' Federation on the question of the wages of operators of mechanical coal-cutting machines was heard in Manchester in private on Thursday of last week by Mr. Charles Doughty, K.C., who was appointed by the Board of Trade to decide the dispute between the two bodies. The rate of pay in connection with the working of these machines is not uniform throughout the two counties, and the contention of the miners' representatives is that the rate is unduly low in some instances. The decision is to be announced at a later date, and interest in it is enhanced by reason of the fact that its effects will probably be national rather than local.

Storage Tanks for the Air Ministry.

A contract for a number of large steel tanks for the storage of petrol at the Abingdon Aerodrome, Oxford, was recently placed by the Air Ministry with the Dowson and Mason Gas Plant Company, of Levenshulme, Manchester.

Industrial Results.

The depression in the Lancashire textile machinery industry is reflected in the announcement of the directors of Tweedales and Smalley (1920), Ltd., Castleton, near Rochdale, that no dividend will be paid on the ordinary shares for the year ending April 30th last. The firm, which is not a member of the Lancashire textile machinery combine, paid a dividend of 7½ per cent. in the previous year and one of 10 per cent. for the year 1929–30. An increased profit is disclosed in the annual report of Richard Johnson and Nephew, Ltd., wire manufacturers, of Bradford, Manchester, for the year to the end of March last, the figure of £34,990 comparing with £31,914 in 1930–31. The distribution to the ordinary shareholders is increased from 5 to 7 per cent.

Non-ferrous Metals.

Price conditions on the non-ferrous metals markets during the past week have been variable, but in no instance has there been any very decided weakness, although buying interest so far as the consuming industries are concerned has been on a restricted scale. In the case of tin there is a fair amount of confidence in the ultimate effect on prices of the new restriction programme of producers, but notwithstanding there has been some profit-taking in evidence, and this has resulted in a loss on balance compared with a week ago of about £1 per ton. A top-heavy statistical position in the copper market, coupled with a marked absence of buying interest on any important scale, continues to be a very depressing influence and a fall in standard brands of the metal of rather more than £1 per ton has brought values down to new low levels. Offers of lead during the past week have been plentiful, and no more than a quiet business has been reported. At one time there was a further loss in quotations, but a recovery since has brought prices in this section of the market to about where they were a week ago. Spelter prices are about 1s. per ton lower on balance, but, although the demand shows little improvement, the undertone is believed to be reasonably steady at the moment.

Iron and Steel.

Extremely quiet conditions as the result of the holidays, which have been observed at varying length by the leading Lancashire iron and steel-using centres, have been experienced this week. Buying in all sections has been virtually at a standstill, and deliveries in many instances have been suspended for the time being. The general price position, however, is more or less where it has been for some time. In the case of foundry pig iron, Staffordshire, Derbyshire, and North-East Coast brands are quoted for delivery to users in the Manchester district at 67s. per ton, with Northamptonshire No. 3 at 65s. 6d., Derbyshire forge iron at 62s., Scottish No. 3 at about 86s. 6d., and West Coast hematite at 81s. The superabundance of scrap material is said to be responsible in no small degree for the poor business that has been done recently in pig iron. With regard to bar iron, Lancashire best quality bars are maintained on the basis of £10 5s. per ton, with Crown bars at £9 15s. In the steel market, boiler plates are not too strong at about £8 12s. 6d. per ton for acid and basic kinds, but small re-rolled bars are fairly steady at about £7 per ton, whilst joists at £8 15s., sections at £8 17s. 6d., ship and tank plates at £8 17s. 6d., and large diameter bars at £9 7s. 6d. are all unchanged compared with recent levels.

The Late Mr. J. H. Nuttall.

I regret to have to record that Mr. J. H. Nuttall, joint managing director of David Bridge and Co., Ltd., passed away on Saturday, May 14th, at the age of sixty-seven years. He had been connected with the firm for the past twenty-one years, and for the last three years held the position of joint managing director.

BARROW-IN-FURNESS.

Hematite.

The holidays have to a certain extent interfered with what business there is, and naturally the market has been quiet. Makers are still receiving orders representing small tonnages from buyers who are continuing to restrict their orders to immediate requirements. Stocks have come down at various works, and the Barrow company restarted two furnaces this week, and also put the rail mill into operation. This will mean that so long as the steel departments are engaged Barrow stocks will not accumulate. It is possible, if the effect of the tariffs leads to bigger business in iron, that stocks may come down to a very low figure, and there is now quite a definite feeling that the tariffs will result in more business. The Continental and American trade is very quiet, which points to the fact that neither Continental nor American users need much iron at present, otherwise the present price would attract them. There is a slight improvement in the iron ore trade, owing to more furnaces going in, but the business in both native and foreign ore is still very slack. The steel market continues to be dull. A few orders are held, and more would be very welcome. When present foreign stocks are exhausted it will be easier to gauge the general trend.

SHEFFIELD.

(From our own Correspondent.)

Steel Trade Quieter.

THIS has been a broken week in the Sheffield trades, few of the firms having worked more than half the full number of days, owing to the Whitsuntide suspension. The national returns show that the output of steel ingots and castings in the country during April was 433,300 tons. This was 35,000 tons more than was recorded in April, 1931, and was equal to last year's monthly average; but it compared unfavourably with the 462,000 tons of March and the 480,600 tons of February, although it was somewhat better than the 429,700 tons of January. There is little buying on a tonnage basis, or for forward delivery, most consumers contenting themselves with the covering of immediate requirements only. The amount of business transacted during the past fortnight has been very small, and consumers are offering very low prices. In some cases, they regard 32s. 6d. or 33s. as adequate, but merchants are not satisfied with these figures.

Lighter Departments.

Some of the lighter manufacturing branches continue to enjoy considerable activity, thus presenting a bright contrast to the heavier side. A good volume of work is being turned out in the departments dealing with stainless, heat-resisting, and corrosion-resisting steels, and there is a brisk demand for steel parts for motor vehicles. The recent increase in activity in steel strip, both hot and cold-rolled, is not fully maintained, but work still continues on a large scale, while the conditions in regard to wire and permanent magnets are also fairly satisfactory. Tools are in good request on home account, but the export side, particularly in regard to the Far East, is unsatisfactory. Only a moderate amount of trade is reported at the file works. The crucible steel branch is slack, taken as a whole, but has its moderately good parts.

Tariff Revision.

People engaged in various Sheffield trades are hoping for alterations in the recently announced tariff rates. In most cases, they are asking for an increase, but in one they are desirous of a reduction. The last-named relates to the Swedish iron bars used for making crucible steel. The new Tariff Order treats this iron as semi-manufactured material, and puts it in the 33⅓ per cent. category. Members of the trade are of opinion that this has been done inadvertently, as they understand that the Committee originally intended to treat such iron as raw material, subject to a duty of 10 per cent. The increases asked for relate to pig iron, finished steel, tools, and cutlery. Steel makers are pressing for the duties on semi-manufactured and finished steel goods to be made uniform at 33⅓ per cent. This figure already applies to semi-manufactured goods, but on finished products the present rate is only 20 per cent. These representations are at present before the Tariff Advisory Committee, and the uncertainty as to their outcome is having the effect of checking business to a considerable extent.

English Steel Appointments.

The English Steel Corporation has appointed as works director Mr. A. B. Winder, and, as commercial manager, Mr. A. Dunbar. The former is at present general manager and director of Industrial Steels, Ltd., and the latter is commercial manager of the Elswick works of Vickers-Armstrong, Ltd., and special director of that company. Mr. Winder is well known in Sheffield, where he has already had a long career in the steel trade. He is a son of the late Rev. J. H. Winder, vicar of Woodhouse, near Sheffield. He studied metallurgy under Professor Arnold, and is a Mappin gold medallist. He went direct from the Technical School to the works of Thos. Firth and Sons, Ltd., in 1894. In 1908 he was appointed manager of the new Siemens plant put down by Jonas and Colver, Ltd. Ten years later he returned to Messrs. Firths' as head of their Siemens department, and eventually became general manager and director of Industrial Steels, Ltd.

Professor and the Salerni Process.

Professor Wheeler, Professor of Fuel Technology at the University of Sheffield and Director of the Safety in Mines Research Stations at Sheffield and Buxton, desires, in view of reports which have appeared in the Press, that it should be clearly understood that he is in no way concerned with the commercial exploitation of the Salerni process of low temperature carbonisation. He has given advice and assistance in the technical development of this process, such as, in his position as Professor of Fuel Technology, he gives in any other coal industry problem, but he is not in any way concerned commercially in this particular process.

Cutlery and Plate.

Trade in table knives and other ordinary lines of cutlery, as well as in silver and electro-plate, continues very dull, retailers in the home market placing orders very sparingly. The improved position of scissors, surgical instruments, and safety razor blades, however, is maintained. The returns of overseas trade, both outward and inward, are much more favourable than formerly. Exports of cutlery in April amounted to £77,668, as compared with £62,280 in March. Safety razors and blades showed a very satisfactory gain from £37,767 to nearly £48,000, the highest figure which this department has ever made. The four months' figures are £95,345 for blades—compared with £46,914 last year—and £37,918 for complete razors—compared with £24,000. The April return also showed an improvement in both scissors and knives. South Africa proved to be an improving market, her purchases rising from £4000 in March to £9200 in April, while the trade with Canada more than trebled. On the import side the value in April was only £9669, showing some fall on March. The total imports for the four months of this year have amounted to £35,292, which represents a substantial fall, the figure for 1931 having been no less than £239,930, and that for 1930, £167,127. Work has been commenced on the preparation of premises which have been taken in Sheffield by a German firm for the manufacture of scissors, and a quantity of machinery from Germany has been installed. There is to be an interesting exhibition of Sheffield goods at one of the great London stores for a fortnight, beginning on Monday next. The display will embrace not only cutlery and plate, but a great variety of tools, refractory materials, and the work of the Applied Science Department of the University, and will also include working demonstrations in cutlery, electro-plating, spring coiling, boring square holes in wood, machine and hand file cutting, saw piercing of silver, and hand raising of silver.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron Trade.

HOLIDAY influences have interrupted the normal flow of business in the Cleveland pig iron trade this week, and very few transactions have been recorded. Con-

sumers are still adhering rigidly to their policy of buying merely for early needs, a policy they are able to pursue with comparative comfort because of the keen competition among sellers for orders, and of the fact that in nearly every case prompt delivery of almost every class of material is obtainable. Moreover, prices are more or less stabilised. During the past few weeks the output of Cleveland pig iron has been passing steadily into consumption, but the demand does not warrant the restarting of any more blast-furnaces. Stocks have increased a little this week, owing to most of the consuming works being closed down for two days and deliveries being suspended. Except for sale in Scotland, where special concessions are made, Cleveland pig iron prices are :—No 1 foundry, 61s.; No. 3 G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; and No. 4 forge, 57s.

Hematite Pig Iron.

There is little change to note in the condition of things in the East Coast hematite pig iron trade, and the market continues on the quiet side. Consumers are still showing little inclination to place orders, except for small tonnages to cover immediate needs. Orders, however, are just sufficient to absorb the output. Producers are anticipating an improvement in both home and Continental demand, and are inclined to take a firmer stand. Mixed numbers are quoted at 63s. 6d. and No. 1 quality is at a premium of 6d. per ton.

Iron-making Materials.

The foreign ore trade continues dull and featureless. Consumers have large stocks, and have no necessity to enter the market. Best Bilbao Rubio is nominal at 15s. 6d. c.i.f. Tees. The coke market shows no signs of activity, and good medium blast-furnace qualities are freely offered at 15s. 9d., delivered at the works.

Manufactured Iron and Steel.

Producers of finished iron and steel in this district are now meeting with a fair measure of success in their bid for orders, and the industry presents a distinctly brighter outlook. The fact that a contract has been secured by Dorman, Long and Co., Ltd., from Montreal for 1000 tons of tramway rails, in face of keen American competition, is regarded as of considerable importance, and very encouraging. Hopes are now entertained that further Canadian orders will be secured, the devaluation of the pound sterling having placed manufacturers in this country in a favourable position for obtaining trade in the Dominion. Constructional engineers keep fairly busy on work in hand, but there has been a lull in fresh inquiry lately. An improved demand for sheets is reported. Prices are steadily maintained.

The Coal Trade.

There has been little movement in the Northern coal trade this week, the market being under holiday conditions. No sign of any revival in the demand for Northumberland steam coal can be discerned, and it is proving difficult to find openings for clearance of current production. The position, however, is strongly against fitters, and output has accordingly to be curtailed. Small coal is still being dumped on the ground. Best Northumberland steams are plentifully offered at 13s. 6d., with small abundant at 8s. 6d. Prime West steams are dull, large being at 15s., but small somewhat scarce and firm at 12s. Tyne primes are in good supply and easy in tone, best at 12s. 9d. to 13s., and small at 9s. The foregoing prices can be discounted through contract holders. Little interest is noticeable in the Durham coal trade. All descriptions are offered freely, and very few producers are fully booked up. On the whole, gas coal output is well earmarked, but buyers can still cover at recent prices, and for later in the month supply is abundant. Best qualities are at 14s. 6d. Wear special gas coals are plentiful, despite idle time at many mines, but 15s. is indicated by sellers. Secondary gas coals are offered at 13s. to 13s. 6d. and coking coal at 12s. to 12s. 9d. The demand for bunker coal has fallen off, and the present position is very disappointing as compared with that of a few weeks ago. Superior brands are obtainable at the minimum of 13s. 6d. to 13s. 9d., and good seconds at 13s. Stocks of coal are increasing as makers decline to quote at lower prices, and buyers hold off. Best gas coke is quoted at 18s.; patent oven coke, 14s. to 14s. 6d.; superior makes, 16s. to 18s.; coke nuts, 16s. to 18s.

Coal Contract.

A coal contract for 30,000 tons of Tyne prime steam small has been arranged this week for the Memel Electricity Works. Prices are not disclosed, but are stated to be on the basis of the fixed minimum f.o.b. values. This is the first time for years that these buyers have not contracted for Polish fuel.

SCOTLAND.

(From our own Correspondent.)

Dull Markets.

IN the steel, iron, and coal trade activities continue at a low level. Certain industries consume a modest amount of material with fair regularity, but some of the usually larger avenues of disposal are almost entirely closed up meantime. General export inquiries are moderate, but actual business is very slow to materialise.

Steel.

Makers of heavy steel are still poorly supplied with specifications, and there is little prospect of improvement until there is a change in the conditions of industry in general and at the shipyards in particular. Sheet makers are somewhat better off, although they have not been so busy of late. The amount of business pasaing in light sheets is fairly well maintained, but heavy black sheets are slow. Galvanised descriptions are comparatively inactive. Prices have not been advanced to the extent necessary to cover the duty on raw materials, and producers experience considerable difficulty in securing remunerative business. Tubes are in very quiet demand, and most of the works in this district are at a standstill. It is reported that owing to the new tariffs, the International Tube Cartel has decided not to export gas, water, and steam tubes to this country.

Iron.

The position in the bar iron trade has not shown the slightest sign of improvement, and producers have difficulty in maintaining even a modest degree of employment. The home price is fixed on the basis of £9 15s. per ton for Crown quality, but the export quotation of £9 5s. per ton is open to variations. Re-rolled steel bars at £6 10s. home and £6 7s. 6d. per ton export are more or less neglected. The home price is rigidly adhered to, but £6 5s. per ton might be done for export.

Pig Iron.

Supplies of pig iron are more than equal to the demand, even with only six furnaces in blast. Last week a consignment of over 5000 tons of pig iron arrived in this district from Calcutta.

Scrap.

The market for scrap is dull, merchants having difficulty in moving even small lots, and prices are easy at 37s. 6d. for heavy steel, 32s. 6d. heavy basic, and 47s. 6d. to 50s. per ton cast iron machinery.

Coal.

The ruling conditions in the coal trade have not appreciably changed during the week. The strike in the Fifeshire area has almost fizzled out, the collieries at Bowhill being the only pits now inactive. The market is still affected to some extent, Fifeshire and Lothians steams being still firmer, with treble and double nuts—especially the latter—strong. Navigations are easy in all districts. The export trade is still severely handicapped by restriction of imports into many Continental countries, some of which discriminate against the admission of British coal. As a rule it is only possible to secure orders for even small lots when very keen prices are quoted. Aggregate shipments amounted to 233,009 tons, against 240,230 tons in the preceding week and 207,112 tons in the same week last year. Home demands continue to diminish with the advance of the year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Coal Trade.

A CERTAIN amount of satisfaction is to be derived from the statistics relating to the coal export trade for the month of April, as this district shared in the increased volume of British trade. Exports reached the total of 1,426,881 tons, which was 218,948 tons better than for the preceding month. Furthermore, the value improved by £249,553 to £1,324,297, and the average price rose 9d. to 18s. 6½d. per ton f.o.b. It is rather doubtful whether the figures for the current month will equal those for April, as the tonnage position during the past few weeks has not been favourable, except at Swansea, where anthracite coals are mainly shipped. Still, the returns issued by the Great Western Railway Company of the coal and coke shipped at the ports in this area under its control are fairly good for last week, as the total came to 460,330 tons, which compared with 396,330 tons for the preceding week and with 469,794 tons for the corresponding period of last year. In considering last week's total, the fact must be borne in mind that special efforts were made to get vessels away so as to avoid their being detained right over the holidays, and further, as there was no work at the docks on the two first days of this week, it is inevitable that the figures relating to shipments for this week will show a material reduction as compared with a normal period. Conditions generally have been quiet owing to the holidays, and it will be next week before business settles down. So far as can be seen comparatively little new business has come along over the holidays, though it is understood that the contract for the requirements of the Egyptian State Railways has been placed with T. Beynon and Co., Ltd., for the whole quantity of 240,000 metric tons, in respect of which that firm put in tenders on the basis of 24s. 3d. c.i.f. Alexandria for 180,000 metric tons, and 17s. 11d. f.o.b. for 60,000 metric tons. Although the prices are considered low, the order will be welcomed by the Monmouthshire collieries, delivery being over the next four months. The news from France is not too pleasant, as, although nothing official has come to hand yet, it is reported that it is the intention of the French Government to cut down the quantity of coal imported immediately. Up to now the quantity allowed has been 64 per cent. of the average monthly quantity for 1928–30, with a margin of 6 per cent., making a total of 70 per cent., whereas it is understood that from henceforth the quota will be reduced to 50 per cent., but that a margin of 10 per cent. will be retained for allocation at the disposal of the French Mines Department.

Brisk Shipments at Swansea.

Judging from the daily returns of vacant loading berths at South Wales docks under the control of the Great Western Railway Company, it would appear that work has not been by any means brisk, but when the figures for last week are analysed it will be found that the port of Swansea was an exception, and that by far the bulk of the vacant loading berths were at Newport, Cardiff, Penarth, and Barry. As a matter of fact, on Saturday last the total for the whole of the ports was forty-nine, but only four of these were at Swansea, and earlier in the week, instead of there being vacant berths there were vessels waiting to berth. As often happens some owner was unfortunate in not getting his vessel away before the holidays, with the result that as work was not resumed this week until Wednesday, this owner loses the best part of a week, which is a costly matter in these times when freights are so unremunerative. A case of hardship has been cited, this being a 3000-ton steamer which arrived at Swansea on Thursday morning, but was unable to get into a berth until Friday afternoon, although her cargo and bunkers were ready for her on the Thursday. This steamer was unable to complete loading before the vacation and therefore could not get away before to-day. The fact that she did not sail on Saturday last means that she also lost the week-end at her discharging port, which is Nantes. This is very unfortunate for the owners. The Great Western Railway Company's reply to this complaint is the advice that exporters should make more use of the adjoining port of Port Talbot, where there were idle tips; but, of course, this means extra leadage on the coals. The suggestion was also put forward by the exporting firm interested in the loading of the steamer that at times of heavy loading pressure arrangements should have been made for an extension of working time on the Saturday, so as to assist steamers to get away. As a matter of fact shipowners and exporters, when discussing holiday arrangements with the trimmers' leaders, endeavoured to get the latter to agree to work being restarted on Tuesday of this week instead of Wednesday, but the men's leaders would not agree. The suggestion of the Great Western Railway Company's chief docks manager that more use should be made of the facilities at Port Talbot to ease the pressure at Swansea is not one that appeals to Swansea traders who are anxious to keep all the trade they can get. Their contention is that the Great Western Railway Company should meet the position by additional manning of the coal tips at Swansea, and that its failure to do so is responsible for the congestion which has prevailed lately at that port.

Coalfield Items.

A certain amount of trouble has broken out in the anthracite section of the coalfield, as the workmen at the Gwaun-cae-Gurwen have tendered notices to terminate their contracts at the end of this week as a protest against the management dismissing one of the hands "without proving any offence against him." Hopes are entertained that as the result of meetings between the parties a stoppage of work will be avoided before the end of this week. Notices were also served at the end of last week upon 400 of the 1200 men employed at the Tymawr Colliery of the Great Western Railway Company, Pontypridd, which is a subsidiary of the Powell Duffryn Company.

Steel and Tin-plate Trade.

Quite a number of tin-plate works have been idle this week. At the works in the Llanelly group of Messrs. Richard Thomas and Co. notices were posted up on Saturday last intimating that there would be no work this week and indicating that fresh notices would be issued at the end of this week. In contrast with this, however, the smelting furnaces at the Elba Steel Works, Gowerton, were operated throughout the holidays. The rolling and mill departments at the works only had one day's holiday, on Monday. A second mill giving work to an additional eighty men has been restarted at the Landore, Swansea, works of the British Mannesmann Tube Company, consequent upon the Iraq order for 26,000 telephone and telegraph poles.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

D. NAPIER AND SON, Ltd., announce that Sir Harold Snagge, K.B.E., has been appointed chairman of the company, and that Mr. Leonard Williams has been elected to a seat on the board as an executive director. Mr. Frederick A. Davies, who is also a director of the company, retains his position as general manager.

THE STANTON IRONWORKS COMPANY, Ltd., near Nottingham, having acquired a controlling interest in the Wellingboro' Iron Company, Ltd., has decided to erect a new furnace plant similar to the modern plant recently set to work at Stanton. The present furnace plant will be kept in operation up to July 31st next, when the reconstruction work will be taken in hand.

CONTRACTS.

AN order has been placed with the English Electric Company by the Galloway Water Power Company through its consulting engineers, Messrs. Merz and McLellan, for five large water turbine alternator sets and three auxiliary sets for the Tongland and Glenlee power stations, together with a considerable quantity of switchgear and transformers. The water turbines will be constructed at the company's Rugby works, and will form the largest order for this class of product so far undertaken at that factory. The generators and other material will be made at Stafford Works.

CATALOGUES.

DRESSING AND SCREENING COMPANY, Ltd., Mansfield-road, Alfreton.—Catalogues on "Drescol," "Rastex," "Gumco," &c., sieves and screens.

BRITISH OXYGEN COMPANY, Ltd., Angel-road, N. 18.—Booklets on "Oxygen Cutting Machines," and "Hints on Oxy-Acetylene Welding."

PATERSON HUGHES ENGINEERING COMPANY, Ltd., Lochburn-road, Maryhill, Glasgow.—List 16 of "Phee" electric hoist blocks and overhead runways.

DRAYTON REGULATOR AND INSTRUMENT COMPANY, Ltd., West Drayton, Middlesex.—List No. 171 of electric automatic temperature control equipment.

B. ELLIOTT AND CO., Ltd., St. Pancras Works, Belle Isle, York-road, N. 7.—A leaflet describing the "Matchless" interchangeable point self-lubricating lathe centre.

ENGLISH ELECTRIC COMPANY, Ltd., Stafford.—Publication No. N. 36, entitled "Truck Switchgear, Size 2-A"; publication No. N. 38, entitled "The Application of the Induction Voltage Regulator."

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	16/6 to 20/–
(1) Spanish	17/– to 22/6
N.E. COAST—	
Native	18/– to 21/–
Foreign (c.i.f.)	15/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 8 6	—
No. 1 Foundry	3 12 0	—
No. 3 Foundry	3 9 6	—
N.E. COAST—		
Hematite Mixed Nos.	3 3 6	3 3 6
No. 1	3 4 0	3 4 0
Cleveland—		
No. 1	3 1 0	3 1 0
Siliceous Iron	3 1 0	3 1 0
No. 3 G.M.B.	2 18 6	2 18 6
No. 4 Foundry	2 17 6	2 17 6
No. 4 Forge	2 17 0	2 17 0
Mottled	2 16 6	2 16 6
White	2 16 6	2 16 6
MIDLANDS—		
(c) Staffs.—	(*Delivered to Station*).	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 1 0	—
„ „ Foundry	3 6 0	—
(c) Northampton—		
Foundry No. 3	3 2 6	—
Forge	2 17 6	—
(c) Derbyshire—		
No. 3 Foundry	3 6 0	—
Forge	3 1 0	—
(3) Lincolnshire—		
No. 3 Foundry	—	—
No. 4 Forge	—	—
Basic	—	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	3 15 6 (a) / 4 0 6 (b) / 4 5 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	9 15 0	9 5 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 5 0	—
Common Bars	9 5 0	—
Best Bars	10 5 0	—
Double Best Bars	10 15 0	—
Treble Best Bars	11 5 0	—
LANCS.—		
Crown Bars	9 15 0	—
Second Quality Bars	8 5 0	—
Hoops	12 0 0	—
S. YORKS.—		
Crown Bars	9 15 0	—
Best Bars	10 15 0	—
Hoops	12 0 0	—
MIDLANDS—		
Crown Bars	9 0 0 to 9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 5 0	—
Gas Tube Strip	10 10 0	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates (Marine)	9 0 0	8 10 0
„ „ (Land)	—	—
Ship Plates, ½in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	7 15 0	7 15 0
Sheets (Gal. Cor. 24 B.G.)	10 15 0	10 0 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 15 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	7 2 6	—
Soft Billets	5 10 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	6 10 0 to 9 0 0	—
MANCHESTER—		
Bars (Round)	9 7 6	—
„ (Small Round)	7 0 0	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	8 12 6	—
SHEFFIELD—		
Siemens Acid Billets	9 2 6 (basis)	—
Hard Basic	8 2 6 and 8 12 6	—
Intermediate Basic	6 12 6 and 7 2 6	—
Soft Basic	6 0 0	—
Hoops	9 10 0 to 9 15 0	—
Soft Wire Rods	7 10 0	—
MIDLANDS—		
Small Rolled Bars (all British)	7 5 0 to 7 15 0	—
Small Re-rolled Bars	6 7 6 to 6 10 0	—
Billets and Sheet Bars	5 5 0 to 5 10 0	—
Galv. Sheets, f.o.b. L'pool	9 7 6 to 9 10 0	—
(2) Staffordshire Hoops	9 10 0	—
(*d*) Angles	8 7 6	—
(*d*) Joists	8 15 0	—
(*d*) Tees	9 7 6	—
(*d*) Bridge and Tank Plates	8 17 6	—
Boiler Plates	8 7 6 to 8 10 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14 f.o.b.	14/6 to 15/3
Block Tin (cash)	120 0 0
„ (three months)	122 0 0
Copper (cash)	29 7 6
„ (three months)	29 10 0
Spanish Lead (cash)	10 16 3
„ „ (three months)	11 2 6
Spelter (cash)	12 10 0
„ (three months)	12 16 3
MANCHESTER—	
Copper, Best Selected Ingots	33 0 0
„ Electrolytic	34 10 0
„ Strong Sheets	63 0 0
„ Tubes (Basis Price), lb.	0 0 9½
Brass Tubes (Basis Price), lb.	0 0 9
„ Condenser, lb.	0 0 11½
Lead, English	13 0 0
„ Foreign	11 5 0
Spelter	12 15 0
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

Tungsten Metal Powder	2/3½ per lb.	
Ferro Tungsten	2/– per lb.	
	Per Ton.	Per Unit.
Ferro Chrome, 4 p.c to 6 p.c. carbon	£25 12 6	7/–
„ „ 6 p.c. to 8 p.c.	£24 10 0	7/–
„ „ 8 p.c. to 10 p.c.	£23 15 0	6/6
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£37 15 0	10/–
„ „ „ 1 p.c. carbon	£48 0 0	12/–
„ „ „ 0·70 p.c. carbon	£52 0 0	13/–
„ „ „ carbon free	1/1 per lb.	
Metallic Chromium	3/– per lb.	
Ferro Manganese (per ton)	£11 0 0 for home	
„ „ „	£11 10 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£10 0 0 scale 5/– per unit	
„ „ 75 p.c.	£17 15 0 scale 7/– per unit	
„ Vanadium	12/9 per lb.	
„ Molybdenum	6/3 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£250 to £255	
Ferro Cobalt	8/9 per lb.	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	13/–
„ „ Ell	14/3
„ „ Splint	14/3 to 15/6
„ „ Trebles	11/6
„ „ Doubles	9/9
„ „ Singles	8/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	12/–
„ „ Jewel	16/6
„ „ Trebles	12/–
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	11/– to 12/–
Screened Navigation	16/6
Trebles	11/– to 13/–
Doubles	10/– to 10/6
Singles	8/9
LOTHIANS—	
(f.o.b. Leith)—Best Steam	11/– to 11/6
Secondary Steam	11/–
Trebles	11/– to 11/6
Doubles	10/–
Singles	8/9

(8) N.W. COAST— ENGLAND.

Steams	21/9
Household	32/6 to 51/8
Coke	20/– to 22/6
NORTHUMBERLAND—	
Best Steams	13/6
Second Steams	12/3 to 12/6
Steam Smalls	8/6
Unscreened	12/6 to 13/–
Household	27/– to 39/–
DURHAM—	
Best Gas	14/6
Second	13/3 to 13/6
Household	25/– to 37/–
Foundry Coke	24/–
SHEFFIELD—	Inland.
Best Hand-picked Branch	25/– to 26/– —
South Yorkshire Best	20/– to 21/– —
Derbyshire Best Bright House	20/– to 21/– —
Screened House Coal	16/– to 17/6 —
Best Screened Nuts	16/– to 17/– —
Small Screened Nuts	13/6 to 14/6 —
Yorkshire Hards	16/– to 18/– —
Derbyshire Hards	16/– to 18/– —
Rough Slacks	8/6 to 9/6 —
Nutty Slacks	7/– to 8/6 —
Smalls	5/– to 6/– —
Blast-furnace Coke (Inland)	12/– to 12/6 on rail at ovens
Furnace and Foundry Coke (Export), f.o.b., 15/6 to 17/6	

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	19/6 to 19/9
Second Smokeless Large	18/9 to 19/6
Best Dry Large	19/– to 19/6
Ordinary Dry Large	17/9 to 18/3
Best Black Vein Large	18/3 to 18/6
Western Valley Large	17/9 to 18/–
Best Eastern Valley Large	17/7½ to 17/9
Ordinary Eastern Valley Large	17/3 to 17/6
Best Steam Smalls	13/– to 13/6
Ordinary Smalls	11/– to 13/–
Washed Nuts	19/– to 25/–
No. 3 Rhondda Large	19/6 to 19/9
„ „ Smalls	15/– to 16/–
No. 2 „ Large	17/– to 17/3
„ „ Through	15/6 to 16/–
„ „ Smalls	14/– to 14/3
Foundry Coke (Export)	22/6 to 36/6
Furnace Coke (Export)	17/– to 18/–
Patent Fuel	19/– to 19/6
Pitwood (ex ship)	19/– to 20/6
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	36/– to 38/6
Seconds	27/– to 32/6
Red Vein	22/6 to 27/6
Machine-made Cobbles	41/6 to 48/6
Nuts	40/– to 48/6
Beans	28/6 to 32/6
Peas	19/– to 21/–
Breaker Duff	8/6 to 9/6
Rubbly Culm	8/3 to 8/9
Steam Coals:	
Large	20/– to 20/6
Seconds	18/– to 20/–
Smalls	11/6 to 13/–
Cargo Through	16/– to 17/6

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate: Joists (minimum), 22/6; Ordinary Ship, Bridge, and Tank Plates and Sections, 15/– if home consumers confine purchases from associated British Steel Makers. (*e*) Delivered Black Country Stations.

French Engineering Notes.

(From our own Correspondent in Paris.)

Industrial Agreements.

THE iron, steel, and engineering trades in this country were the last to be drawn into the world slump, because, normally, there is a deficiency of French workers, which has to be made good by imported labour, and when business began to decline they were the foreigners who left and it was only later that unemployment extended to all classes of French workmen. At the same time, an organised effort was made to check the decline by stimulating public works, for which large sums of money have already been voted, but as the funds have not yet been raised the projected undertakings have done little to help the manufacturing industries and the situation has become steadily worse. The railway companies must distribute the considerable orders that have remained in abeyance for more than a year, and while some business will be given out shortly the financial situation of the companies compels them to move with extreme caution. The merchant marine is stagnant, and nothing can be hoped for in that direction. The hydro-electric schemes provide some work for electrical engineers, and contracts are looked forward to at a more or less distant date. In the building trades operations are almost at a standstill, which means that all the industries dependent upon them are suffering from complete inaction. So far, the efforts to make up for the decline of foreign business by concentrating on the home trade have not given the expected results, and it is becoming more and more evident to French manufacturers that they must devote their attention to a reorganisation of foreign business. They have been awakened to this necessity partly by the conferences of Mr. Pezzani, a member of Parliament in Mauritius, who has long advocated closer commercial relations between France and Great Britain. He informed the Association des Grands Ports Français last week that Great Britain had been forced to adopt a policy of protection because it was shut out by tariff walls everywhere, and he indicated that the French shared largely the responsibility for the existing state of things. Their only hope, he said, was to enter into negotiations with the British with a view to determining some satisfactory basis of exchange. A step in that direction has already been taken by the woollen manufacturers, who have arranged with Belgian and Dutch firms, and provisionally with Italian firms, for a proposal to be made to the respective Governments to adopt a lower tariff, which will be the same for all countries, on condition that a similar agreement can be come to with British manufacturers. If these negotiations prove successful it is hoped that they may be extended to the engineering and all other industries, so that eventually there will be a really sound European economic union. The British change of front has caused a reaction against excessive tariffs, and the idea now is to fix low international rates.

Colonial Trade.

A plank of safety to which manufacturers have been clinging is the possibility of developing the colonial trade so that, whatever may be the general economic situation, there will always be some basis of industrial activity. The idea is to render this country self-supporting and thus relieve it of the severe effects of a world crisis from which everyone is now suffering. Taking into account the area of the colonies and the population, it is believed that there exist all the elements for an interchange of raw material and manufactured goods. This fact was impressed upon the French public last year by the Exhibition, when it was expected that confidence in the colonial future would release public money for the construction of railways, roads, ports, and other works that are to facilitate transport over vast areas. Under present conditions it is quite futile to attempt to raise the money. Nevertheless, the colonial propaganda continues with the idea that it will eventually bring the public round to an active participation in colonial development, which is to become a leading factor in national prosperity. It is now seen that the African colonies are not likely to become such good customers for manufactured goods as was supposed, for the reason that the wants of native populations in tropical regions are few, and it has not been possible to do much in the way of creating a demand for French manufactures. The colonies continue to absorb a fair amount of structural steel work and plant for public undertakings, but these activities have been slowed down for financial reasons arising out of the ruinously low prices for produce and the enormous accumulation of stocks, while private companies suffer from speculation and there have been costly mistakes in railway construction. Much may be done in the future, such as the installation of factories for vegetable oils instead of sending the raw product to France for treatment, but there is no hope of any large amount of business at present, and manufacturers must necessarily turn their attention to the European trade.

The Steel Trade Organisation.

In the present hopeless condition of the international steel trade it is worth noting that the French organisation is giving quite satisfactory results in the home market and that prices are being maintained, despite the fact that the means of production far exceed the restricted home needs. Any improvement in demand following upon the execution of the programme of public works would give some vitality to the steel making industry. This state of things is only rendered possible by the import quotas, and it will be interesting to see to what extent the future Government will continue a policy that is benefiting some interests to the detriment of others. There is reason to hope that the indiscriminate methods so far adopted will at least be modified. In Belgium it is stated that the banks have come to the assistance of steel makers who find themselves in a critical situation as the result of the closing of foreign markets, and it is regarded as almost certain that one effect of this intervention will be to compel producers to organise their industry in the direction of collaborating with foreign steel makers for a reduced output and price maintenance. For the moment the French are looking solely to their own market and are leaving the Steel Cartel to look after itself, with the idea that national agreements may eventually give more positive results than the international combination, although they will not avoid competition in neutral markets.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

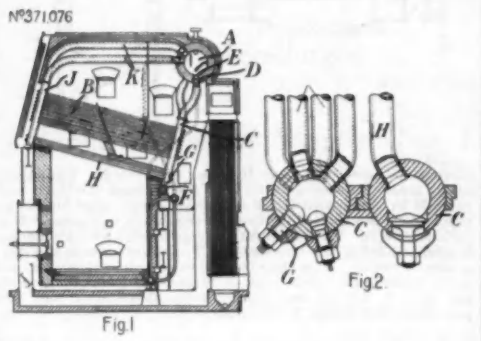
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

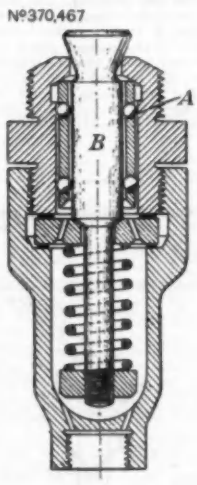
371,076. February 6th, 1931.—WATER-TUBE STEAM BOILERS, *Babcock and Wilcox, Ltd., Babcock House, Farringdon-street, London, E.C.* 4.

The boiler described in this specification is specially suitable for the generation of steam at high pressure, and is constructed to reduce the resistance to flow of the fluid, especially through the uptake and downtake connections. The downtake connections between the water space of the separating drum A and the lower ends of the tubes B are formed by tubular downcomers C of substantially constant cross section, which are connected directly into the steam and water drum by having their upper ends expanded against tube seats D formed in the outer ends of tube receiving openings E extending radially through the drum shell. Alternate downtake connections C



are connected to openings E in different rows to provide the necessary ligament strength. The lower ends of the tubular downcomers are nippled to a mud drum F. The horizontally inclined steam generating tubes are positioned in the usual staggered arrangement and the lower ends are curved as shown in Fig. 2, so as to enter the associated tubular downcomers C in radial directions through openings which are offset in the manner illustrated to provide the necessary ligament strength. Fittings G enclose the openings, which give access to the tubes. The slag screen tubes H enter the downcomers in the manner shown on the right of Fig. 2. In the same way the upper ends of the tubes B are connected to the tubular uptake headers J, which are bent in a gradual curve and extend horizontally to the drum A, the horizontal portions K being located in different planes.—*April 21st*, 1932.

INTERNAL COMBUSTION ENGINES.

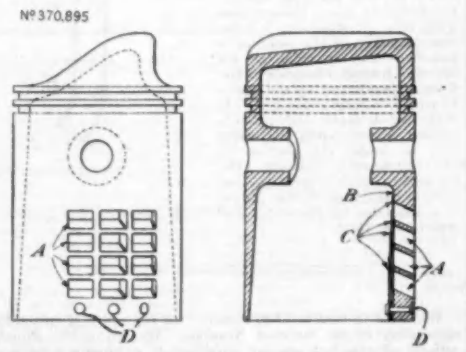


370,467. November 29th, 1930.—FUEL INJECTORS FOR INTERNAL COMBUSTION ENGINES, Alexander Abramson, of Fochova 87, Prague XII., Czechoslovakia.

To ensure a uniform lifting of an oil injection valve, the inventor proposes to use a ball cage A between the valve body and valve spindle B, as shown, and in this way troubles due to non-uniform temperature and wear are claimed to be avoided. The ball cage is free to move in the valve casing, and when the valve is opened, it is pressed against a shoulder on the upper part of the casing by the oil fuel.—*March 29th*, 1932.

370,895. December 9th, 1930.—INDUCTION OF THE CHARGE IN INTERNAL COMBUSTION ENGINES, John Haynes, of 20, Darnley-street, Brooks Bar, Manchester.

The improvements described in this specification refer

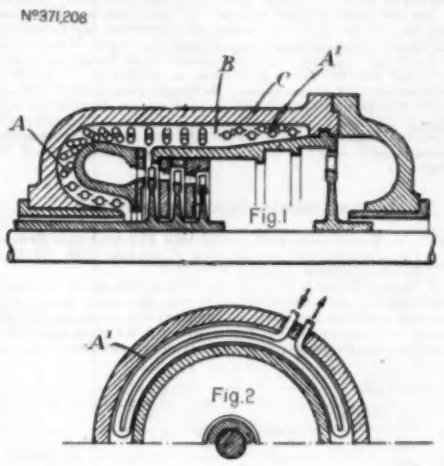


more particularly to internal combustion engines of the kind in which a charge for the cylinder is first drawn into the crank case through co-acting ports in the cylinder wall and piston skirt, and is subsequently compressed in the crank case and transferred to the cylinder above the piston. In such a construction of engine the entering charge has also been employed to effect a cooling of the piston. The object of the invention is improved control of the induction of the charge. In the skirt of the piston there are holes A collectively forming a port and inclined upwardly. The inner wall of the piston skirt is formed as a flat-machined face B, with four thin spring steel strips C forming a laminated valve over the holes. The strips C are secured by rivets D at the bottom of the piston skirt.—*April 11th*, 1932.

TURBINE MACHINERY.

371,208. June 18th, 1931.—STEAM OR GAS TURBINES, Aktiengesellschaft der Maschinenfabriken Escher Wyss et Cie., of 19, Hardturmstrasse, Zürich, Switzerland.

In order to keep the high temperature away from the casing of a high-pressure and high-temperature steam or gas turbine, it is proposed to cool the casing on the inside by means of cooling devices in the space between the casing and the members which deliver the driving medium. The pipes A are traversed by a cooling medium which absorbs and carries off the heat radiated from the inner parts of the turbine, so that undue heating of the inside of the casing is avoided. The medium forced through the pipes A may be a propulsive medium, similar to that used for driving the turbine, or it may be a liquid. In the space B there are cooling pipes A^1, curved in the manner shown in Fig. 2, and are attached to the lower or upper half of the casing C, and superheated steam may be passed through these pipes to prevent condensation of the superheated steam entering the space B. It is important to realise, the inventors explain, that entirely different steam pressures exist inside the pipes, and in the space

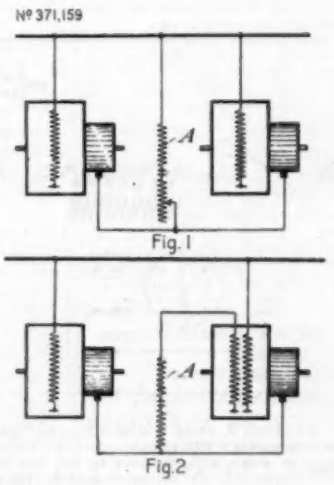


B. Let it be assumed, for example, that the cooling steam flowing through the pipes is under a pressure of 20 atmospheres, and that its temperature is 350 deg. Cent. This steam is, therefore, superheated, as a pressure of 20 atmospheres corresponds to a saturation temperature of 212 deg. Cent. In the space B, on the other hand, the steam pressure may be assumed to be about 100 atmospheres and the temperature 550 deg. Cent. A steam pressure of 100 atmospheres corresponds to a saturation temperature of 309 deg. Cent. Thus, notwithstanding the fact that superheated steam at 350 deg. Cent. flows through the pipes, it is capable of exerting a cooling action on the steam at 550 deg. Cent. present in the space B. It is not, however, able to cool down the steam in the space B to the saturation temperature of the latter—that is to say, to 309 deg. Cent., below which temperature condensation would take place. Obviously, it would not be possible to avoid condensation of the steam in the chamber B if the steam flowing through the pipes A were maintained only at saturation temperature, *i.e.*, 212 deg. Cent., assuming the cooling steam to be at a pressure of 20 atmospheres. —*April 21st*, 1932.

DYNAMOS AND MOTORS.

371,159. April 10th, 1931.—STATOR-FED THREE-PHASE SHUNT COMMUTATOR MOTORS, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

The invention relates to an arrangement for attaining synchronous operation of stator-fed three-phase shunt commutator motors. According to the invention, several shunt motors are provided with one exciter transformer in common, which feeds the commutator windings of all the motors by having its secondary connected to the brushes of all the motors, as shown



in Fig. 1. The new arrangement offers the advantage of simplicity, as the exciter transformer is required in any case for the shunt motor for the purpose of regulating the speed. In addition, the new arrangement differs fundamentally from the methods heretofore employed for attaining synchronous running of asynchronous motors. A common exciting transformer A feeds the commutators in parallel, and the primary of the exciter transformer is fed from the mains. In the arrangement shown in Fig. 2, the primary winding of the exciter trans-

former A is connected to an auxiliary winding in the stator of the commutator motor. The exciter transformer may be either an ordinary core transformer with or without tappings, or an induction regulator or double induction regulator.—*April 21st*, 1932.

TRANSFORMERS AND CONVERTERS.

370,389. December 29th, 1930.—ELECTRICAL TRANSFORMERS OR SIMILAR INDUCTIVE APPARATUS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2.

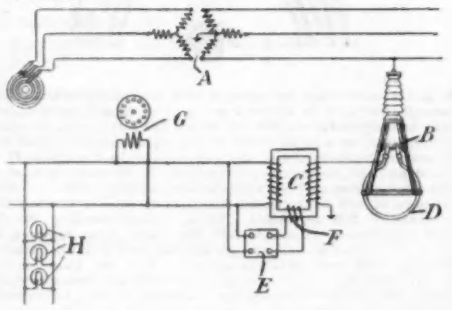
This specification covers a matter which seems to be giving rise to a considerable amount of attention at the present time, *i.e.*, the elimination of the noise or hum caused by the operation of static transformers and similar apparatus. It has been discovered that all the noise may be removed if the assembled core and coils of transformers are impregnated with a molten compound which sets hard and holds all the parts together. The impregnating compound consists of rosin and asphalt, which are combined by heat and fusion in a treating tank. While the proportions may vary, the inventors preferably employ a mixture consisting of about 70 parts of rosin to about 30 parts of asphalt. The rosin employed is preferably one which has a relatively high softening or flow point and a very low viscosity, and high surface tension at the temperature at which the transformers are worked. The asphalt should preferably have a relatively low flow point in the neighbourhood of about 75 deg. to 85 deg. Cent., and a viscosity of about 600 at 150 deg. Cent. The mixture of rosin and asphalt is thoroughly agitated in the treating tank to ensure even distribution of the components. The assembled core and coils are placed in the molten compound, which should be maintained at about 160 deg. to 175 deg. Cent. until the preliminary ebullition of gas and moisture has ceased. At this point it will be found that the composition has penetrated between the laminations of the steel parts of the core. Where the depth of penetration or thickness of insulation is not greater than about 2in. a period of from ten to fifteen minutes is sufficient to meet the requirements of the process. A longer period than this may injure the insulation and set up destructive distillation of the organic material. The transformer is then removed and cooled, when the composition sets hard and holds all the parts together, giving a unit which is solidly and firmly united.—*March 29th*, 1932.

TRANSMISSION OF POWER.

370,637. March 25th, 1931.—ELECTRIC DISTRIBUTION SYSTEMS, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2.*

A cheap scheme is described in this specification for tapping high-tension systems in order to provide small loads at low pressure to farms, &c. The high-tension line is energised through a step-up transformer A. For stepping down from, say, 220 kV to 110 volts a capacitive reactance B and transformer C are used.

N°370,637



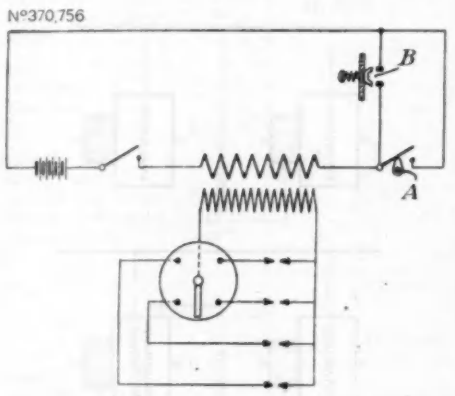
The former consists of an oil-filled cable type coupling capacitor composed of a loop of oil-filled metal-sheathed cable D with its core connected to the line and its sheath earthed through the primary of the transformer. For compensating the drop at various loads a regulator E controls the current flowing in a regulating winding F. G and H represent motor and lamp loads respectively. The regulator E, which is described in considerable detail, involves the use of a grid controlled full-wave rectifier. —*April 14th*, 1932.

MOTOR CARS AND ROAD VEHICLES.

370,756. July 3rd, 1931.—BATTERY IGNITION SYSTEMS FOR MOTOR VEHICLES, Robert Bosch Aktiengesellschaft, of 4, Militärstrasse, Stuttgart, Germany.

In accordance with this invention, an ignition system is interrupted for short periods by bridging over the interruptor A

N°370,756



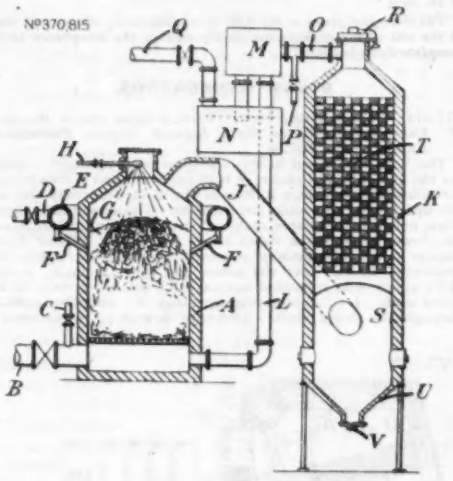
by means of a switch B, which is returned to the "off" position by means of a spring. The scheme offers the advantage that the contacts in series with the lead to the ignition coil are eliminated. Apparently the inventors consider the method to be particularly advantageous on motor cycles.—*April 14th*, 1932.

MISCELLANEOUS.

370,815. September 14th, 1931.—THE MANUFACTURE OF CARBURETTED WATER GAS, *Humphreys and Glasgow, Ltd., of Humglas House, Carlisle-place, Westminster.*

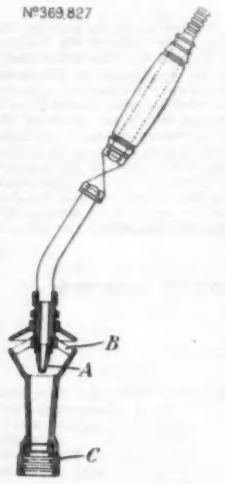
The apparatus described in this specification is for the manufacture of carburetted water gas. A indicates the generator with the fuel bed. The generator is provided with the air blast supply B and the steam supply C for up air blasting and up steaming. There is also provision for introducing secondary air at the top of the fuel bed comprising the air supply D, bustle pipe E, and pipes F. This secondary air produces the marginal hot zone indicated at G. The generator is also provided with the oil supply pipe H adapted to spray oil on the hot zone. The gas offtake J leads to the superheater K, and the gas offtake L leads from the base of the fuel bed

N°370,815



through the three-way valve M to the wash box N. The superheater is also connected to the wash box through the three-way valve M by connection O. P is a steam supply pipe for down-running. Q is a gas offtake from the wash box to storage. R is the stack valve. The superheater is constructed with a chamber S arranged below the checkerbrick T, and into which the connection J enters. This chamber serves as a dust separator and is preferably provided with a hopper bottom as U with the door V for the removal of accumulated dust and fuel particles.—*April 14th*, 1932.

N°369,827



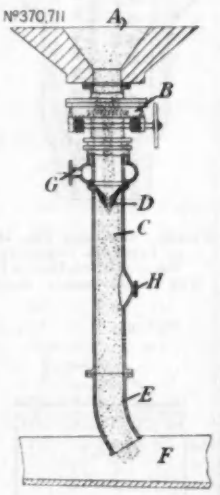
369,827. July 3rd, 1931.—PRESSURE GAS BURNERS FOR SOLDERING PURPOSES, Selas Aktiengesellschaft, Mullerstrasse 10/11, Berlin, N. 65, Germany.

This tool is described as a blow-pipe for soldering with gas under pressure, and the aim is to get a long flame of intense heat. The gas is supplied through the nozzle A and entrains air, through the adjustable orifice B, at a high velocity. The outlet from the burner is of divergent form, as shown at C, and is also grooved. The sharp edges of these grooves have the effect of checking the outside layer of the issuing gases to a velocity below that of ignition, but the central core is projected forward as a long and intense flame. — *March 31st*, 1932.

370,711. May 23rd, 1931.—COMBUSTION RESIDUES FROM FURNACES, *Babcock and Wilcox, Ltd., of Babcock House, Farringdon-street, London, E.C. 4.*

This invention relates to apparatus for the dust-free removal of ash and clinker, &c., from boiler and other furnaces. The ash and clinker, &c., collect during the intervals between discharge in the hopper A, pass centrally through the regulating valve B into the discharge pipe and thence into the water bath D. Here they are saturated with water and fall through the terminal bend E into the flushing channel F. Since no substantial change of direction of the muddy mixture of ash and water formed from the combustion residues occurs beneath the water bath D, blocking of the discharge pipe C or of the bend E is impossible, even if the valve B were not fully closed. Experiments have shown that with this arrangement a dust-free discharge of the residues is possible. The entrance of air into the furnace chamber or the flues is prevented by the valve B, which is fully described. It may be desirable to provide several water baths in series and to make the portion of the apparatus beneath the regulating valve of greater cross section than that of the valve. G is the inlet for the water and H an aperture for poking.—*April 14th*, 1932.

N°370,711



WE have to thank "Mr. Punch" for his courtesy in sending us a copy of his Summer Number. We enjoy Mr. Punch's artistic efforts, but are not qualified to express a considered opinion upon them. In regard to his literary efforts, we may, however, venture to offer the homage due to a master. His literary pillory, lifted from the Press and the library, is a liberal education in how not to write English. The study of it should be introduced into the curricula of all technical schools.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Tuesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

PHYSICAL SOCIETY.—At the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. 7. Editing Committee Meeting, 3.30 p.m.; Council Meeting, 4 p.m.; Meeting at 5 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, W. 1. Discourse, "Faraday at the Sign of the Hexagon: Coal Colour and Constitution," by Professor H. E. Armstrong. 9 p.m.

SATURDAY, MAY 21ST.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Yorkshire District meeting, to be held at Dewsbury.

TUESDAY AND WEDNESDAY, MAY 24TH AND 25TH.

SOCIETY OF GLASS TECHNOLOGY.—Tuesday: Science Museum, South Kensington. Council Meeting, 4.30 p.m. General Meeting. "Some Research Problems in Applied Chemistry," by Professor G. T. Morgan, F.R.S. 7.30 p.m. Wednesday: "The Electrical Conductivity of Sodium-Metasilicate-Silica Glasses," by Dr. E. Seddon, Dr. E. J. Tippett, and Professor W. E. S. Turner; "The Colour of Selenium Ruby Glass," by Mr. H. P. Rooksby (communication from the research laboratories of the General Electric Company, Ltd., Wembley); "The Influence of Thermal Treatment on the Opacity of Fluorine Opal Glasses," by Professor I. I. Kitaigorodsky and Mr. S. I. Kurovskaja; "The Viscosity-temperature Relationship and the Nature of Glasses," by Mr. S. C. Waterton. 2.15 p.m. Trocadero Restaurant, Piccadilly, W. 1. Annual dinner and dance. 7 p.m. for 7.15 p.m.

WEDNESDAY, MAY 25TH.

BRITISH SCIENCE GUILD.—At the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Polar Lights," by Professor Sydney Chapman, F.R.S. 4.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Wireless Section Meeting. "Our Present Knowledge of the Ionized Regions of the Upper Atmosphere," by Professor E. V. Appleton, F.R.S. 6 p.m.

THURSDAY, MAY 26TH.

INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Hotel Metropole, Leeds. Annual general meeting, 7.30 p.m. The students' annual meeting will be held at 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W. 1. Ordinary general meeting for the election of members, 6.15 p.m. Special general meeting, 6.30 p.m. annual general meeting, 6.45 p.m.

ROYAL AERONAUTICAL SOCIETY.—In the Science Museum, Aeronautical Section, South Kensington, S.W. 7. Twentieth Wilbur Wright Memorial Lecture, "New Methods of Research in Aeronautics," by Mr. H. E. Wimperis. Annual Council dinner. Reception and conversazione.

FRIDAY, MAY 27TH.

INSTITUTE OF TRANSPORT.—Joint meeting with the Town Planning Institute and the National Housing and Town Planning Council. "Planning and Transport," by Mr. G. L. Pepler. 6 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, W. 1. Discourse by Sir Walter Morley Fletcher. 9 p.m.

SATURDAY, MAY 28TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Meeting at Whitby. Royal Hotel, Whitby. 1 p.m.

WEDNESDAY, JUNE 1ST.

INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND STUDENTS' SECTION.—Visit to Hull Docks. Leave General Post Office, City-square, Leeds, 9 a.m.

MONDAY, MAY 30TH, TO FRIDAY, JUNE 3RD.

INSTITUTION OF ELECTRICAL ENGINEERS.—Summer meeting at the North Midland Centre. For provisional programme see page 379.

WEDNESDAY TO SATURDAY, JUNE 1ST TO 4TH.

INSTITUTE OF TRANSPORT Congress at Buxton. For programme see page 523.

TUESDAY TO FRIDAY JUNE 7TH TO 10TH.

INSTITUTE OF BRITISH FOUNDRYMEN.—Annual Conference at Newcastle-upon-Tyne. Particulars may be obtained from the Hon. Conference Secretary, Mr. J. W. Eckford, 4, Mosley-street, Newcastle-upon-Tyne.

WEDNESDAY TO FRIDAY, JUNE 15TH TO 17TH.

INSTITUTION OF MINING ENGINEERS.—Summer meeting at Sheffield. Wednesday, general meeting at the Royal Victoria Hotel, Sheffield. Address of welcome by the Lord Mayor of Sheffield. Presentation and discussion of papers, 11 a.m. The meeting will be adjourned at 1 p.m. and resumed at 2.30 p.m. Reception of members and ladies by the Lord Mayor and the Lady Mayoress of Sheffield at the Town Hall, 4.30 p.m. Reception of members and ladies at the Royal Victoria Hotel, Sheffield, by the President and Council of the Midland Institute of Mining Engineers, followed by a cabaret show and dance, 8.30 p.m. Thursday, visits to various works, 10.30 a.m. Institution of Mining Engineers' dinner at the Royal Victoria Hotel, Sheffield, followed by informal dance, 7.30 p.m. Friday, visits to various works, 11 a.m.

TUESDAY TO SATURDAY, JUNE 21ST TO 25TH.

BRITISH WATERWORKS ASSOCIATION.—Bournemouth. Annual general meeting and conference. For programme see page 422.

SUNDAY TO SUNDAY, JUNE 26TH TO JULY 10TH.

WORLD POWER CONFERENCE.—Sectional meeting in Scandinavia. For provisional programme see page 405.

FRIDAY, JULY 1ST.

OVERHEAD LINES ASSOCIATION.—Summer meeting at Chesham. For provisional programme see page 513.

MONDAY TO TUESDAY, JULY 4TH TO 12TH.

INTERNATIONAL ELECTRICAL CONGRESS, 1932.—Particulars may be obtained by intending British visitors from the Secretary of the Institution of Electrical Engineers, Savoy-place, Victoria Embankment, London, W.C. 2.

TUESDAY, JULY 5TH, TO SATURDAY, JULY 9TH.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.—Royal Show at Southampton.